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STRUCTURAL DIFFERENCES BETWEEN GREATER AND LESSER WAX MOTH[1]

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Some few years ago, by vote of the members of the American Association of Economic Entomologists, the committee on Common Names of Insects designated the name *wax moth* as the official American common name for the greater wax moth. This insect has also been known as the bee moth and wax worm, but to date no action has been taken on an official name for the lesser wax moth. With this in mind, it is thought desirable to use the name greater wax moth in this discussion as was done by recent workers, since the two wax moths are to be compared.

The interesting account in the November 1935 issue of *Gleanings in Bee Culture*, entitled "Lesser vs. Greater Wax Moth," by V. G. Milum (*3*), describes the differences between these two hive pests and clears away a lot of confusion that has existed in the past as to the identity of these two insects. This article also quotes the extensive German work of Kunike (*2*) in which the lesser wax moth is described in some detail.

In the articles of both Milum and Kunike the emphasis on distinguishing characters is based on color in the adults and habits and type of injury in the larval stage. Since color is as variable as the size, the adults would be difficult to identify, if found outside of the hive. Moreover, it is conceivable that an apiculturist might be called upon to distinguish the dead larvae removed from the hive and sent in for identification. Habits would then be of no avail and the two distinct types of injury would not be apparent. After Milum's article was published, he was asked what features of the bodies would distinguish the two species, since neither his nor Kunike's article stresses these points. It was pointed out by him that none of the available literature on the subject stressed these points. Through the kindness of Dr. Milum the writer was supplied with specimens of the wax moths for study and the following is offered, by way of supplement to his article, to distinguish the two species on the basis of body structure.

[1] Contribution 180 from the entomological laboratories of the University of Illinois.

Adult differences.—Milum has pointed out that the lesser wax moth adults are silver gray as compared to the mixed or mottled brown and gray of the greater wax moth and that the underwings of the greater wax moth are creamy white while the lesser has underwings of the same color as the fore wings. It is a common observation that older specimens of the lesser wax moth which have lost by rubbing, or otherwise, most of their scales, lose also their silvery gray color. Two structural features will serve to separate these moths even when badly rubbed or disfigured.

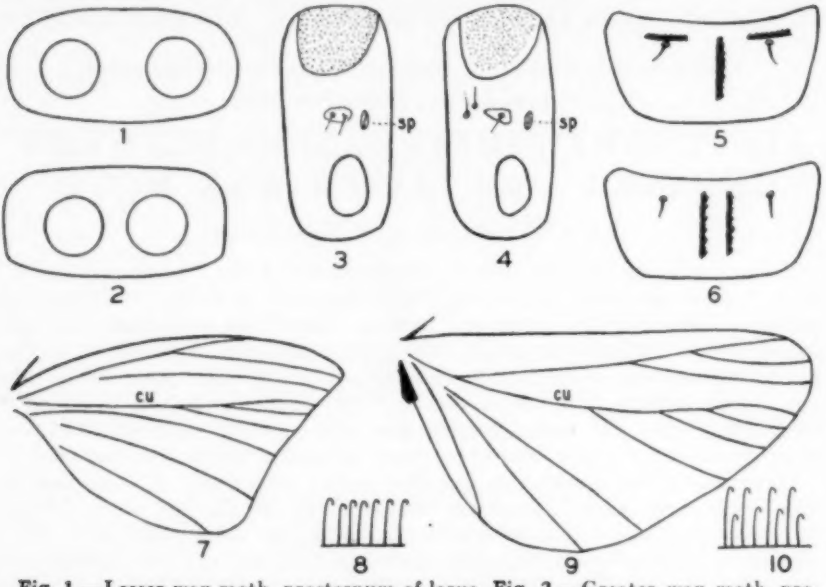

Fig. 1.—Lesser wax moth, prosternum of larva. **Fig. 2.**—Greater wax moth, prosternum of larva. **Fig. 3.**—Greater wax moth, lateral aspect of prothorax of larva. **Fig. 4.**—Lesser wax moth, lateral aspect of prothorax of larva. **Fig. 5.**—Greater wax moth, dorsal aspect of ninth segment of pupa. **Fig. 6.**—Lesser wax moth, dorsal aspect of ninth segment of pupa. **Fig. 7.**—Hind wing of lesser wax moth. **Fig. 8.**—Greater wax moth, hooks or crochets of larval prolegs. **Fig. 9.**—Hind wing of greater wax moth. **Fig. 10.**—Lesser wax moth, hooks or crochets of larval prolegs.

The adult of the greater wax moth bears a conspicuous tuft of hairs on the front of the face that is not present in the lesser wax moth and the hind wings of the greater wax moth has the cubital vein, Cu, apparently four branched, fig. 9, while in the lesser wax moth the hind wing has the cubital vein, Cu, apparently three branched, fig. 7. In each case the condition is brought about by the normally two-branched cubital vein having either one or two branches of the medial vein branching from the cubitus.

Larval differences.—The larvae or worms of the two species may be distinguished as follows:

GREATER WAX MOTH.—The body of the worm is spindle shaped, being broader in the middle; the first segments of the first pair of legs,

known as the coxae, are scarcely or not at all separated from each other, fig. 2; a brownish spot in front of the prothoracic spiracle, Sp., bears two hairs, fig. 3; the hooks on the end of the abdominal legs, known as crochets, fig. 8, are of a uniform length, and according to Fracker (*1*) this is the only member of the family Pyralididae—to which both species belong—that has crochets or hooks of equal length. The hooks on the abdominal legs are arranged in the form of a circle except those on the last pair at the tip end of the abdomen, which are placed in the form of a semicircle. The shield-shaped area, fig. 3, on the top of the first segment of the thorax is a solid brown color.

LESSER WAX MOTH.—The body of the worm is not broad at the middle but more nearly cylindrical; the first segments or coxae of the front legs are separated by a distance equal to about one-half the width of the coxa itself, fig. 1; the brown spot in front of the prothoracic spiracle, fig. 4, has but one hair upon it, but with two other hairs in front of, but not on, the brown spot; the hooks of the abdominal prolegs are of two distinct lengths, fig. 10, and of three lengths on the anal or last abdominal legs. The hooks of the anal legs are more nearly arranged in a transverse line than in the form of a semicircle and the shield of the first segment of the thorax, fig. 4, has its divided halves darker, almost black, near the center, with an encircling ring that is much lighter in color.

The cocoons of the two species are easily separated by the fact that the cocoon of the greater wax moth is whitish and nearly free of wax and excrement pellets while the lesser wax moth has the silken cocoon completely covered with dark pellets of excrement that adhere to it and give it a dark, almost black, color. The pupae themselves, when removed from the cocoons, have not been distinguished from each other. Dr. Edna Mosher (*4*) in her important paper on the classification of the pupae of moths and butterflies studied the structure of the pupa of the greater wax moth but did not have the lesser wax moth for comparison.

Pupal differences.—The following structural differences in the pupae are to be noted:

GREATER WAX MOTH.—A prominent ridge extends along the back over the thorax to the end of the abdomen and only near the front end of the ridge divided into two parallel ridges. Along the crest of the ridge the surface is broken up into strong knobs or crenulations. The back of the ninth segment of the abdomen, fig. 5, has a short transverse ridge that is not present on the other species.

LESSER WAX MOTH.—The prominent ridge extending along the back from the thorax to the end of the abdomen is composed of two closely parallel ridges that are more widely separated on the rear segments. The crest of the ridge is only faintly broken up by crenulations that are not knoblike. The back of the ninth segment, fig. 6, lacks the short, transverse, undulating ridge on each side of the longitudinal ridge.—9-1-36.

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(2) **Kunike, G.** 1930. Zur biologie der kleinen wachsmotte *Achroea grisella* Fabr. Zeits. Angew. Ent. **16**:305–56.
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EASTERN BRANCH

PAPER-READING SESSION, SEVENTH ANNUAL MEETING
Baltimore, Md., November 1935

PEAR MIDGE IN RELATION TO FRUIT SET AND TIMING OF CONTROL SPRAYS[1]

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The pear midge, *Contarinia pyrivora* Riley, often causes serious injury to the pear crop in districts of the Hudson valley and western New York. The adults are small, mosquitolike flies which emerge from the ground usually during the latter part of April and early May. The appearance of the midges seems to be closely correlated with the development of Bartlett pear trees into the cluster bud stage. The eggs are deposited in the expanding, unopened blossom buds and the larvae feed on the ovarian tissues of the fruits. Infested fruits increase in size very rapidly for a time but the complete destruction of the internal tissues soon arrests their development and the resulting gall-like fruits are usually shed from the trees during early summer. Midged pears rarely mature, and if they do they are of no commercial value.

From 1931 to 1933 inclusive, growth studies were made of infested and uninfested pear fruits. Both Clapp and Bartlett varieties were observed, but the data presented here concerns only the Bartlett variety.

A number of fruit clusters were tagged about the time of petal-fall, when midge injury could first be recognized by the slightly swollen appearance of the young fruits. In general the clusters were grouped according to the character of the pears borne by them as follows: (1) clusters having uninfested fruits only, (2) clusters having both infested and uninfested fruits, and (3) clusters having infested fruits only. The greatest and least transverse diameters of each selected fruit were measured every second day from petal-fall until about the middle of June, when most of the midged pears dropped. The average diameters of all fruits so measured were computed. The accompanying graph, fig. 1, plotted from the data of typical specimens of infested and uninfested fruits, indicates the rapid initial development of the infested pear, its point of arrest and its retrogression as compared with the uniform rate of growth of the uninfested fruit.

[1] Approved Dec. 24, 1935, by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper 116.

While these studies were in progress it was noted that certain blossom buds were usually selected by the midge for oviposition. It was also apparent that the loss of fruit by harvest time each year was much more extensive than indicated by the number of midged pears observed during early summer. This led to further details of investigation which are given here as preliminary studies.

As some of the first clusters selected for observation proved to be useless because of the dropping of the fruits, necessitating their replacement by other clusters similar in character, the numbers of complete

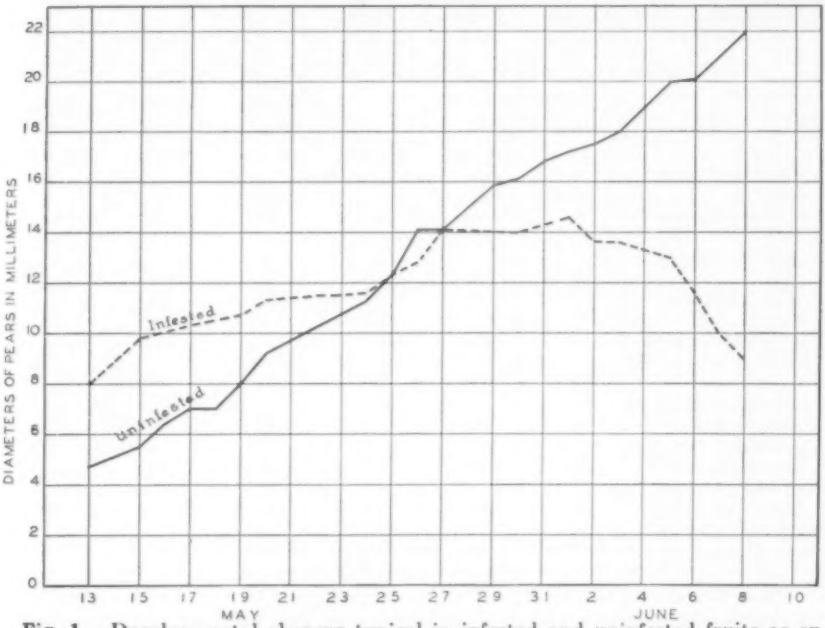

Fig. 1.—Developmental changes typical in infested and uninfested fruits as expressed by their average median transverse diameters.

observations in the various series were automatically reduced. Normally each fruit cluster at the time the studies were begun bore from six to nine, average about seven, blossoms, arranged in a low conical spiral on a central peduncle. Probably the most important factors concerned in determining the number and location of those blossoms which will set and mature fruit are: the vitality of the cluster, climatic conditions, pollination, insect injury and mechanical injury.

A study of the data showed that clusters having only uninfested fruits averaged 1.1 pears per blossom cluster, which represented 60.5 per cent of the original set. Clusters having both infested and uninfested fruits averaged .43 pears per cluster or 15 per cent of the original set. Clusters having only infested fruits dropped all the sets. It will be remembered that the final data were taken about the middle of June so that the above

percentages do not apply to the numbers of fruits reaching maturity. Table 1 shows the per cent loss of fruit during the several years of observations, and it will be noted that the total loss of fruit from clusters having only uninfested pears varied from 25 to 75 per cent. This may be considered as the normal drop for these clusters during the period of study. In the case of clusters having four uninfested pears each, the

Table 1.—Loss of pears from natural causes and from injury by pear midge.

Description of Clusters	No. of Clusters	Total Fruit Lost	Total Fruit Lost from Midge	Uninfested Fruit Lost		
				Based on Total Fruit	Based on Uninfested Fruit	Due to Presence of Infested Fruit
		per cent	*per cent*	*per cent*	*per cent*	*per cent*
1 uninfested pear only	20	25		25	25	
2 uninfested pears only	8	50		50	50	
3 uninfested pears only	15	42		42	42	
4 uninfested pears only	2	75		75	75	
1 infested pear only	30	100	75			
1 infested, 1 uninfested pear	28	88	38	38	75	25
1 infested, 2 uninfested pears	10	93	51	60	90	48
1 infested, 3 uninfested pears	10	73		48	63	
2 infested, 1 uninfested pear	8	88	45	21	63	20
2 infested, 2 uninfested pears	7	86	11	36	71	

small number observed and usually present on Bartlett trees makes it advisable to consider the per cent loss with reservation. The total loss of fruit from clusters having both infested and uninfested fruits varied from 73 per cent for clusters having one infested and three uninfested pears to 100 per cent for clusters having one infested pear only. The loss due to midge was calculated by comparing clusters, each of which bore the same total number of fruits, and is found by subtracting the per cent of normal drop from clusters having uninfested pears only from that of clusters having both infested and uninfested pears. It will be noted that the per cent loss of uninfested fruits from clusters having both infested and uninfested pears is greater in nearly every instance than the normal drop from clusters having uninfested pears only, and the difference in loss of fruit doubtless represents those fruits that dropped because of the influence of one or more midged pears growing in the same cluster. This loss, which varies from 0 to 48 per cent, may be calculated in each instance by subtracting the per cent of normal drop from clusters having uninfested fruits only from the per cent loss of uninfested fruits com-

puted on the basis of uninfested fruits per cluster. It is therefore evident from the data that the presence of one or more infested fruits in a cluster not only destroys that many possibilities for fruit to mature normally but imperils most of the uninfested pears of the same cluster. Whether the dropping of fruit is due to greater food assimilation by the midged pears because of their abnormally rapid growth and consequent starvation of the other fruits of the cluster, or to other physiological factors, is unknown.

During the studies of 1933 it was observed that the infested fruits were often borne on pedicles near the tip or distal end of the peduncle. More than half of the clusters having infested fruits bore these on terminal

Table 2.—Locations of fruits on the peduncles of clusters.

Description of Clusters	No. of Clusters	Clusters with Terminal Fruits	Clusters with Fruits on Any 2 Most Distal Pedicles	Clusters with Fruits on Any 3 Most Distal Pedicles	Clusters with Fruits on Any 4 Most Distal Pedicles
		per cent	*per cent*	*per cent*	*per cent*
Uninfested pears only	8		13	38	38
Infested pears only	10	60	90	100	
1 infested, 1 uninfested pear	10	50	70	90	100
1 infested, 2 uninfested pears	7	57	86	100	
1 infested, 3 uninfested pears	7	14	57	100	
2 infested,1 uninfested pear	7	86	86	100	
2 infested, 2 uninfested pears	7	86	100		

pedicles and table 2 shows that in many instances 100 per cent of such clusters bore all the infested fruits on the three most distal pedicles. In no instance were they found farther from the tip of the peduncle than the fourth pedicle. On the contrary, none of the uninfested pears in any of the clusters observed set and remained on terminal pedicles after June 20, the date of the last observations. Clusters having uninfested fruits only, bore them on the two most distal pedicles in but 13 per cent of the cases, and 38 per cent of such clusters had fruits on the four most distal pedicles. The series of diagrammatic drawings of fruit clusters, fig. 2, show the location of the pedicles on the peduncles, and the comparative sizes of those fruits that dropped and of those remaining on June 20.

There are probably few insects which allow the fruit grower as narrow a time limit for control sprays as occurs in the case of the pear midge. The critical period for treatment is determined by the stage in development of the blossom buds when oviposition is possible, and also by the extent of fly emergence as indicated by trap cages. Since the first midges appear usually before the blossom buds swell appreciably and are constantly testing them for oviposition possibilities, a delay of 24 hours in timing the treatment may, under some conditions, fail to give control. Cold

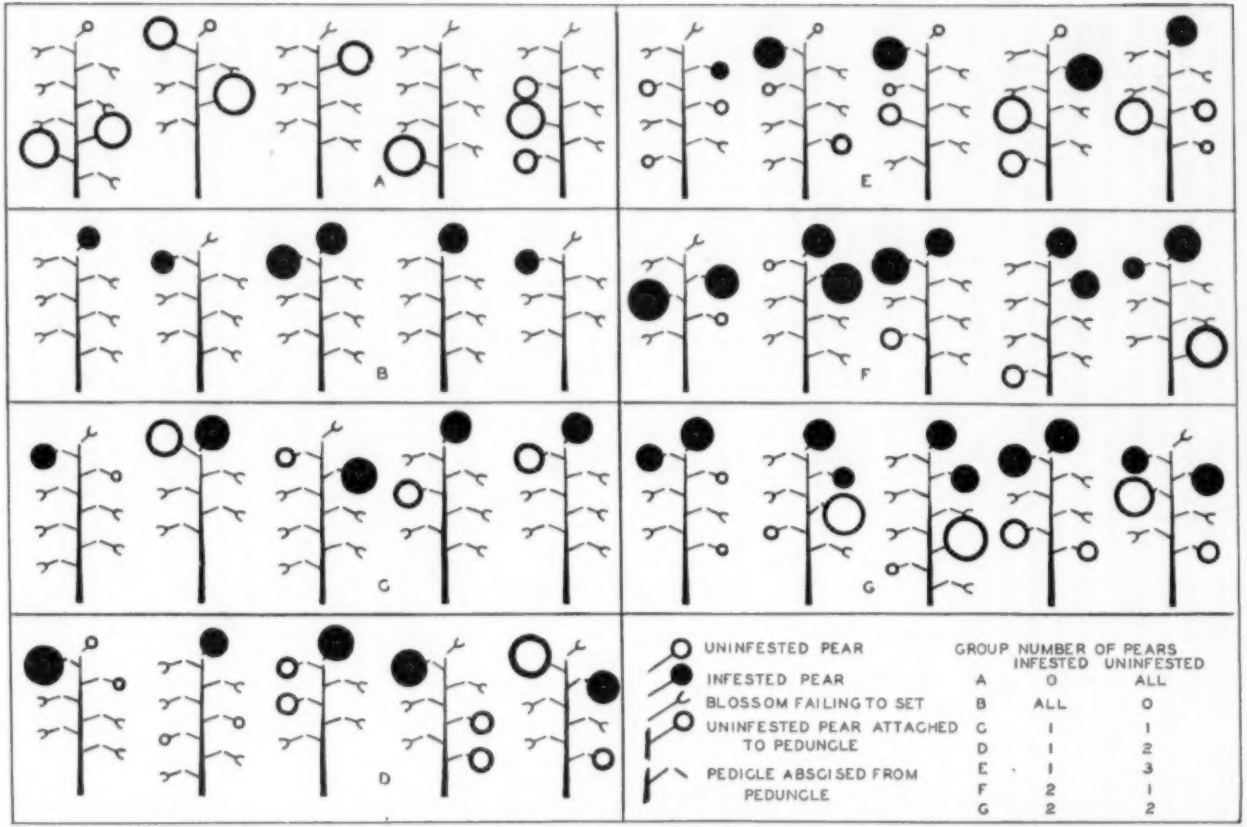

Fig. 2.—Typical development of pear fruits on infested and uninfested fruit clusters. The diagrams indicate the relative size of the fruit at abscission or at the time of the last measurement, June 20. For convenience in drawing, the pedicle is shown as broken midway instead of being separated at the peduncle, as is normal.

weather sometimes arrests the development of the blossom buds while in the stage suitable for egg laying. When this occurs and when the emergence period is prolonged, two sprays may be necessary for efficient control. However, due to the expense involved and the usual limited time for operation, one control treatment is advisable in most seasons.

Discussion.—Midge-infested fruits in some way not well understood cause a shedding of uninfested fruits growing in the same cluster. Where midge infestation is heavy, therefore, the crop may be seriously depleted. The midges oviposit usually in the four most distal blossom buds on the peduncle. Normally, blossom buds nearest the base of the peduncle are most likely to set and mature fruits. Control sprays timed to destroy the flies before they are able to oviposit in any of the four most advanced blossom buds afford the best protection against pear midge.—9-1-36.

COTTON STATES BRANCH

PAPER-READING SESSION, ELEVENTH ANNUAL MEETING
Jackson, Miss., February 5–6, 1936

FIELD MOVEMENT OF BOLL WEEVILS IN RELATION TO INITIAL INFESTATION AND RAINFALL

G. L. SMITH and M. T. YOUNG, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*[1]

During the years 1933, 1934 and 1935, screens coated with a sticky substance were placed in nine fields near Tallulah, in Madison parish, La., and the numbers of boll weevils collected on these screens were recorded semiweekly. The monthly increase and season's total collection of boll weevils on these screens each year appear to have an almost direct relation to the total rainfall and the number of days with .3 inch

Table 1.—Field infestation by overwintered boll weevils, Tallulah, La.

YEAR	DATE	NO. PLANTS EXAMINED	NO. BOLL WEEVILS FOUND	NO. PLANTS PER BOLL WEEVIL
1933	May 17 to June 6	106,000	1583	67
1934	May 10 to June 6	109,000	2671	41
1935	May 17 to June 13	142,000	1820	78

or more of rainfall during June, July and August, which is the normal fruiting season of cotton in this section. In these three years there was a high and fairly uniform infestation by overwintered boll weevils during May and early in June. In table 1 it is shown that the average infestation by overwintered weevils for 1933 was one weevil per 67 plants examined, for 1934 one weevil per 41 plants and for 1935 one weevil per 78 plants.

[1] Assisted in the field by G. L. Garrison, J. C. Clark, A. L. Scales, and several temporary assistants.

Infestation by overwintered weevils was somewhat higher in 1934 than in 1933 or 1935 and, as table 3 shows, the catch of weevils on screens was likewise higher for June 1934 than for June 1933 or June 1935.

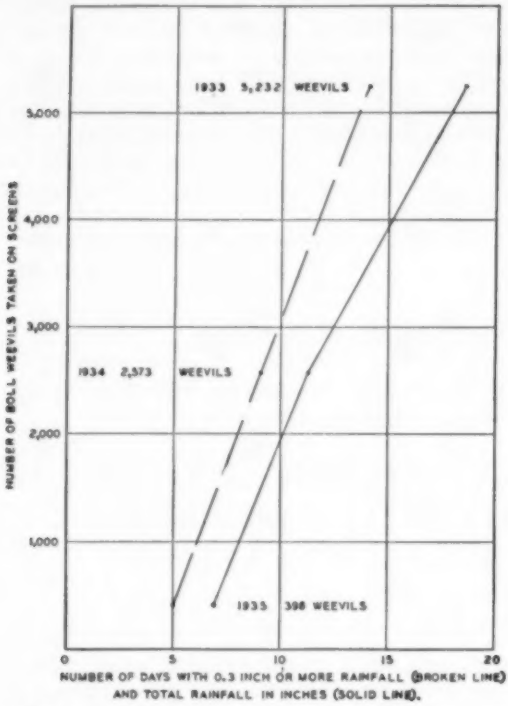

Fig. 1.—Broken line, boll weevil catch from June to November, inclusive, in relation to number of days with .3 inch or more of rainfall during June, July and August. Solid line, boll weevil catch from June to November, inclusive, in relation to total rainfall during June, July and August. Tallulah, La., 1933–35.

Rainfall during June, July and August 1933, table 2, totaled 18.46 inches, and a rainfall of .3 inch or more occurred on 14 days during this period. For the same period in 1934 the rainfall was 11.23 inches with nine days having .3 inch or more of rainfall, and in 1935 the rainfall was 6.89 inches, with five days having .3 inch or more of rainfall. It will be noted in table 3 that the total boll weevil catch on screens from June to November, inclusive, was 5232 in 1933, 2573 in 1934 and 396 in 1935. Thus it is seen that in proportion as there was a decrease in rainfall each season from 1933 to 1935, there was a corresponding decrease in the number of boll weevils collected on the screens. Figure 1 shows that the decrease in the total number of boll weevils collected was almost directly proportional to the decrease in the number of days during June, July and August on which

Table 2.—Rainfall during June, July and August for 1933, 1934 and 1935, and the number of days with .3 inch or more of rainfall, Tallulah, La.

Month	1933		1934		1935	
	Inches Rainfall	Days with .3 Inch Rainfall or More	Inches Rainfall	Days with .3 Inch Rainfall or More	Inches Rainfall	Days with .3 Inch Rainfall or More
June	2.77	2	7.23	5	3.78	3
July	12.84	8	1.81	1	1.35	1
August	2.85	4	2.19	3	1.76	1
Total	*18.46*	*14*	*11.23*	*9*	*6.89*	*5*

Table 3.—Number of boll weevils caught on screens in various fields at Tallulah, La., 1933, 1934 and 1935.

Date	Joan	Montrose Front	Montrose Deadening	Fortune Forks	Banna	Hecla	Barnes	Panola	Scotland	Total
					1933					
June	18	2	11	1	1	2	11	7	11	64
July										72
August	100	67	94	104	245	110	216	222	201	1359
September	95	50	80	191	219	158	294	249	232	1568
October	139	19	32	37	156	63	84	170	214	914
November	77	34	201	47	138	149	222	170	217	1255
Total	*429*	*172*	*418*	*380*	*759*	*482*	*827*	*818*	*875*	*5232*
					1934					
June	8	5	14	3	2	15	7	40	8	102
July	4	4	2	4	49	1	11	60	43	178
August	19	13	28	12	96	25	60	76	55	384
September	9	7	8	5	20	6	8	26	22	111
October	19	51	12	53	77	32	81	278	235	838
November	96	75	32	29	165	70	147	104	242	960
Total	*155*	*155*	*96*	*106*	*409*	*149*	*314*	*584*	*605*	*2573*
					1935					
June	3	1	1	1	1	7	6	6	1	27
July	2	0	4	8	3	6	9	29	6	67
August	13	5	10	5	24	13	15	18	14	117
September	6	3	6	5	9	5	6	5	11	56
October	16	7	3	6	2	9	14	13	46	116
November	2	2	1	1	2	0	3	0	2	13
Total	*42*	*18*	*25*	*26*	*41*	*40*	*53*	*71*	*80*	*396*

.3 inch or more of rainfall occurred. Figure 1 also shows that almost the same ratio of decrease in number of boll weevils collected occurred when compared with the total rainfall during June, July and August for the three seasons.

Table 2 shows that, of the total rainfall and days of rainfall during June, July and August 1933, more than 50 per cent occurred in July, while in 1934 and 1935 more than 50 per cent occurred in June.

Table 3 shows that the heavy catch of boll weevils on screens in 1933 held up through August and September, while in 1934 and 1935 the heavy catch held up only through August. In 1933 a greater number of weevils were caught on the screens in November than in October because in November a greater number of weevils were leaving the fields and seeking hibernation shelter. In 1934 the greater catch of weevils recorded in October and November than during September was due to the fact that, beginning with October and continuing into November, weevils flew from the fields to enter hibernation. In 1935 a smaller number of weevils were caught on the screens in November than during October because most of the weevils entered hibernation during October and the greater proportion of those which remained in the fields in November were killed by sudden cold weather before they had had an opportunity to seek hibernation shelter. There was a shortage of feeding and of breeding material during October on account of the general stripping by leaf worms, *Alabama argillacea*, and the early maturity of cotton, which undoubtedly caused many weevils to fly to distant fields in search of food, thus leaving very few weevils in these fields during November.

Summary.—Comparison of boll weevils in movement, as recorded on screens at Tallulah, La., 1933–1935, shows a positive correlation between number of weevils taken and total rainfall over the corresponding periods. It also indicates a positive correlation between the number of weevils taken and number of days with .3 inch or more of rainfall.—10-5-36.

ADDITIONAL NOTES ON LITTLE-KNOWN COTTON INSECTS

J. W. Folsom, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*[1]

Most of the coleoptera referred to in this paper have not hitherto been recorded from cotton. All are injurious but none are abundant. Their collective damage is of some importance, but these species are incidentally controlled by the customary calcium arsenate treatment for the boll weevil. All the observations on the feeding habits were made in the insectary.

Lactica tibialis Oliv.—Though not on record as a species of economic

[1] The observations recorded herein were made at Tallulah, La., in 1935, with the assistance of P. A. Glick, assistant entomologist, and K. H. Smith, temporary assistant. Species of coleoptera were determined at the U. S. National Museum by H. S. Barber, L. L. Buchanan, E. A. Chapin and W. S. Fisher.

importance, this chrysomelid was rather common on seedling cotton late in May. In the insectary the beetles ate the edges of seed leaves, but always died within three days.

Monachus saponatus (Fab.).—This chrysomelid is not referred to in our literature as an economic species. On leaves of seedling cotton it eats away the upper epidermis and the parenchyma, and occasionally eats holes through the leaves. Small plants may be killed by the beetle.

Bassareus brunnipes (Oliv.).—This chrysomelid beetle, which has not been recorded as an injurious species, ate into and destroyed buds of the cotton plant late in June and early in July. It also gnawed stems and petioles.

Rhabdopterus picipes Oliv.—The larvae of this species damage cranberries and other bog plants by feeding on the roots, and the beetles eat the foliage. On young cotton plants the beetles were found to eat small patches on the upper or the lower surfaces of leaves, and to eat into stems, causing the tops to fall.

Paria sellata Horn.—This chrysomelid ate round holes in cotton leaves and gnawed petioles, causing the leaves to fall. The species had not been recorded as injurious.

Diabrotica balteata Lec.—The food plants of this pest are some 40 in number, mostly plants of the truck garden. On cotton this chrysomelid rags bracts and squares badly, in the same manner as *Colaspis brunnea*. It also eats into the main stems and into squares, which subsequently drop.

Cerotoma trifurcata (Forst.).—In the latter part of June this well-known pest of beans damaged cotton plants by eating large irregular holes in the leaves and irregular gaps in their edges, though the beetles were not sufficiently abundant to strip the leaves to the veins, as they do sometimes on bean plants.

Disonycha glabrata Fab.—During June, beetles of this species ate holes in the stems of small plants, causing the tops to fall, and killed leaves by cutting into the petioles. This chrysomelid was common in the field.

Disonycha collata (Fab.).—This chrysomelid ate the edges of leaves of cotton, without, however, doing very much damage.

Altica foliacea Lec.—Both adults and larvae of this flea beetle damage the foliage of apple and grape, and the species is known as a pest in New Mexico and Arizona. In the middle of May, at Tallulah, La., the beetles destroyed seed leaves and buds of cotton.

Altica rufa (Ill.).—Though not on record as an economic species, this chrysomelid was found to eat irregular holes through cotton leaves, which then died and fell off.

Pachystethus marginata (Fab.).—In June this scarabaeid ate large irregular gaps in the edges of leaves and large irregular holes in the blades. The species was seldom seen on cotton, however, and is not on record as a cotton insect.

Tanymecus confertus Gyll.—Our literature contains two references to this curculio, concerning its damage to young sugar beets. The weevil feeds primarily on various weeds. In late May and early June it was found to feed voraciously on cotton seedlings. It clasps the edge of a leaf

between its legs and moves its head up and down, cutting the leaf in a curve, as does a caterpillar. This weevil kills young plants, but fortunately was not common.

Smicronyx sp.—A species of this genus was not uncommon on cotton plants late in May. In the field the weevils, almost without exception, were found at the nectar gland on the under side of the leaf. In the insectary they ate small irregular holes in the leaves.

Baris interstitialis Say.—Though this weevil has not been recorded as a cotton insect, it damages cotton seedlings by boring holes in the leaves.

Trichobaris trinotata Say.—This important stalk-borer of potato occurred occasionally on cotton plants as an adult only. It fed by scraping away the upper epidermis and parenchyma of a leaf; also by making holes in the stems.

Conotrachelus crinaceus Lec.—From late in May into September this curculionid was common and generally distributed and did considerable damage. The beetle occurred usually in the bud clusters of the cotton plant, where it ate into the buds and killed them. It blasted many young squares and caused older squares to flare, turn yellow and drop. The beetle kills leaves by cutting into the petioles, and kills small plants also.

Ryssematus lineaticollis Say.—This curculio, not hitherto reported as a cotton insect, killed leaves by boring into the petioles, and killed entire plants by gnawing pits in the main stems. Fortunately, it was not common.

Chalcodermus aeneus Boh.—Early in May, this large curculio was found to kill cotton seedlings. The beetle bores into the stem and eats out all the pith that it can reach. As a result the plant withers. This weevil has long been known for its damage to cowpea and beans, and secondarily to cotton, especially to cotton following cowpeas. It seems to prefer the stems and petioles, but also bores into the larger veins of the leaves and into buds. Complaints of damage by this weevil have been frequent.—10-9-36.

BIOLOGY AND ECONOMIC IMPORTANCE OF THE GULF COAST TICK

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The Gulf coast tick, *Amblyomma maculatum* Koch, has been of economic importance locally for many years, but recently, since the screw worm invasion of the Gulf states eastward of Louisiana, it has assumed an economic rank second only to that of the cattle tick, *Boophilus annulatus* Say. This increase in importance is due to the extent to which it encourages screw worm attacks on livestock. As a matter of fact, its

[1] The writers acknowledge the assistance of Carroll Smith, of the Bureau, in performing the engorging, molting and low-temperature tests in the laboratory in Washington, D. C.

high rank as a predisposing cause of screw worm infestation compels the adoption of control measures against it. In turn the development of satisfactory control measures makes necessary a more accurate and complete knowledge of its life history and habits. While investigations of this tick and methods of combating it are still going forward, it seems desirable to make available some of the principal findings to date.

Distribution.—The Gulf coast tick, as the name implies, is restricted in the United States rather closely to the area adjacent to the Gulf of Mexico. It is also found along the Atlantic coast in Florida, Georgia and the southern part of South Carolina. The species is found along the east coast of Mexico and is recorded from Jamaica, West Indies, Colombia, Peru, Ecuador, Chile, Brazil, Paraguay, Argentina and Patagonia.

It is usually less abundant along the Gulf in southwestern Texas than eastward. It is seldom found in numbers farther inland than 100 miles, although a few specimens have been taken at Dallas, Tex., and Memphis, Tenn. The latter were probably brought in on livestock shipped from the coastal region. This distribution suggests that rather high rainfall, humidity and temperature are necessary to its existence. Experimental work tends to confirm this assumption.

Economic importance.—The Gulf coast tick attaches itself largely on the inner surface of the external ear of various animals. Its concentration in these places causes irritation, often resulting in scabbing and cracking of the skin. This condition is distinctly detrimental to livestock. The principal injury, however, is indirect. The ear lesions attract the primary screw worm fly, *Cochliomyia americana* C. & P., which lays its eggs on them. The mass of ticks in the ear causes it to swell and become stiff. This prevents the host from flicking the ear and thus permits blowflies to oviposit undisturbed. The resulting larvae burrow into the ear tissues, and the blood and serum discharged attract other flies. The entire ear may be eaten off in a few days, and the jaw, throat and eye may become infested as a result of the discharges running from the ear. If treatment is neglected, the skull may be laid bare and the animal may die. Even when the larvae are killed rather promptly, the cartilage of the ear is often destroyed so that the ear droops, producing the characteristic "gotch ear" so frequently seen, especially among mules. This type of injury has given rise to the common name "gotch tick" in some localities. The localized attachment in the ears caused the tick also to be called the "ear tick." Since *Ornithodorus megnini* Koch is even more typically an ear tick and this name has been adopted for that species, it is desirable to encourage the use of the name "Gulf coast tick" for *Amblyomma maculatum*.

The great abundance of the seed ticks and nymphs of this species often found on game and other birds suggests that it must be of some importance as a parasite of such birds. This is borne out by the following laboratory experiments: About 100 nymphs were put on each of two juncos and two English sparrows. Five days later a few engorged specimens dropped, and on the following day both juncos and one of the sparrows died. From these birds 26, 26 and 25 engorged nymphs were recovered, and 13 were recovered from the surviving sparrow.

This tick has not been shown to be concerned with the transmission of any disease.

Hosts.—The adults of the Gulf coast tick attack mainly the larger domestic and wild animals, while the larvae and nymphs prefer small wild animals and especially birds. Man is only occasionally attacked. Hooker, Bishopp & Wood (*2*) record cattle, sheep, goat, horse, dog, wolf and man as hosts of adults, and the meadowlark, *Sturnella magna;* bobwhite, *Colinus virginianus;* red-winged blackbird, *Agelaius phoeniceus;* jack rabbit, *Lepus californicus merriami;* and fox as hosts of the nymph.

Bishopp (*1*) lists a number of collections of nymphs from the meadowlark and adds Brewer's blackbird, *Euphagus cyanocephalus,* to the above list. Other hosts of this tick in South America are recorded by various writers (*3*).

The junior author, working in the vicinity of Valdosta, Ga., has found the meadowlark to be the most important host of the immature forms

Table 1.—Incidence of larvae on meadowlarks collected between Valdosta and Alapaha, Ga., 1935.

Inclusive Dates	No. Birds Examined	Percentage of Birds Infested	Av. No. Larvae per Bird	Greatest No. Larvae per Bird	Av. Daily Max. Temp. °F
Oct. 3–15	2	50	78.5	157	81
Oct. 16–31	6	100	17.8	63	82
Nov. 1–15	14	78.5	55	289	77.6
Nov. 16–30	14	42.8	2.4	23	64.3
Dec. 1–15	26	30.7	2.9	46	62.3
Dec. 16–Feb. 15	56	24.4	1.07	32	

during fall and winter months. Of 138 meadowlarks collected between October 1 and February 15, 49.2 per cent were found to be infested with either one or both of the immature forms of the Gulf coast tick. One bird was infested with 289 larvae. During October, November and December the larva was the predominating form. Table 1 gives a good indication of its prevalence. Of the 80 meadowlarks collected during October, November and December, 14.5 per cent were infested with the nymph. Of the 58 collected during January and the first half of February, 43.1 per cent were found infested with this stage. The average number of nymphs per infested bird was 2.54, with 14 as the maximum. The bobwhite, house wren, *Troglodytes aedon;* towhee, *Pipilo erythrophthalmus;* blue jay, *Cyanocitta cristata cristata;* mockingbird, *Mimus polyglottos;* migrant shrike, *Lanius ludovicianus;* gray squirrel, *Sciurus niger niger;* cotton rat, *Sigmodon hispidus hispidus;* and sheep, were found infested with larvae in nature. Other hosts of the adult, as determined by collections made by members of the staff, are coyote, skunk and deer, *Odocoileus virginianus virginianus,* and a nymph was found on a Carolina wren, *Troglodytes ludovicianus.*

Under laboratory conditions larvae were engorged on roof rat, *Rattus alexandrinus;* cotton rat; white-footed mouse, *Peromyscus maniculatus;* pine mouse, *Pitymus pinetorum pinetorum;* red-bellied woodpecker, *Centurus carolinus;* English sparrow, *Passer domesticus;* junco, *Junco hyem-*

alis; pigeon, guinea pig, meadowlark and bobwhite. In some of these tests equal numbers of seed ticks (several thousand) were placed in two glass jars, one containing a white-footed mouse and one a pine mouse. The pine mouse became so heavily infested that it died, 1816 engorged seed ticks being collected, and many hundred partially engorged specimens were found on the jar or remained on the mouse after death, which occurred on the sixth day. On the white-footed mouse only 91 became engorged. The guinea pig proved to be a fairly satisfactory host for the larvae, and the bobwhite was an excellent host.

Life history and habits.—In common with other ticks of this family, this species has four stages: the egg, the larva or seed tick, the nymph

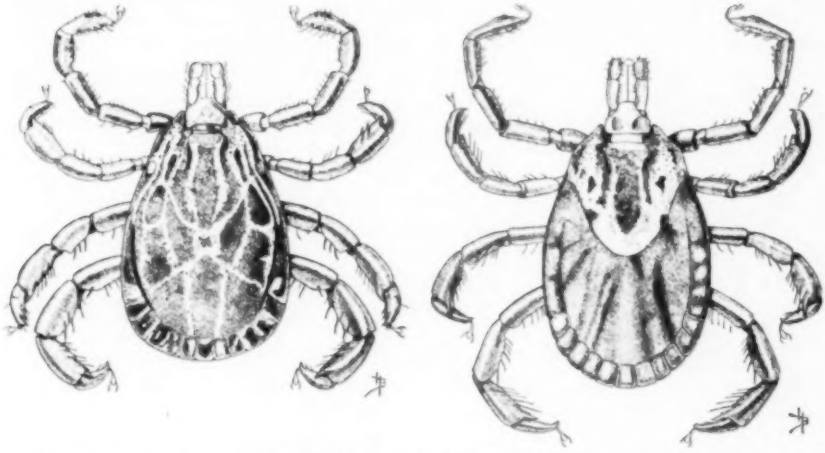

Fig. 1.—The Gulf coast tick. Left, dorsal view of male; right, dorsal view of unfed female.

and the adult. Like other members of the genus *Amblyomma*, it is a three-host species. That is, the larvae and the nymphs drop off the host to molt, and thus the larvae, nymphs and adults may, and probably usually do, engorge on three different hosts.

THE ADULT AND THE EGG.—The mouth parts of the adult are long and inflict a rather severe wound. The species is strikingly marked; the back of the male is netted with iridescent yellowish white lines, and the scutum of the female is largely of this color, the ground color being dark reddish brown, fig. 1. When engorged, the body of the female is leaden gray. The engorged females are larger than any other North American tick, except the gopher-tortoise tick, *Amblyomma tuberculatum* Marx. The female may attain a weight of 1 gram and measures almost 19 mm. in length.

Although the adults usually attach themselves to the inner surface of the ears, they are sometimes found on the outer surface and occasionally on other parts of an animal. Mating takes place on the host. Females apparently do not engorge in the absence of males. Individuals have been

observed to remain on a host for 70 days without engorging. The engorgement period ranges from five to 18 days. The rapidity of engorgement seems to be stimulated if the tick is attached on an ear inflamed from a previous attachment of ticks. When engorged the female drops to the ground, seeks some protected place, and soon begins laying eggs. The males may remain attached for weeks after the females have dropped off the host.

Oviposition may begin as soon as the second day after dropping, and during cool weather, that is, when the average daily maximum is below 70° F, the interval between dropping and oviposition may be greatly prolonged. For instance, one female which detached November 16, 1935, and was kept out of doors at Valdosta, Ga., did not begin ovipositing until January 13, 1936, 58 days later. Oviposition continues for 13 to 75 days.

A female measuring 18 by 13 by 10 mm., kept on moist sand at Valdosta, deposited 18,497 eggs. This is the largest number recorded for any tick occurring in this country. The average number deposited is over 8000.

The eggs are ovoid and dark brown. The incubation period during warm weather, mean temperature 80 to 81° F, is about three weeks. For eggs deposited by females engorged late in the fall this period may extend to nearly five months.

The longevity of unfed adults under laboratory conditions has been shown by Hooker, Bishopp & Wood (*2*) to range from 144 to between 388 and 411 days.

THE LARVA.—Soon after hatching, the larvae crawl about in the grass or weeds, and clusters may be found anywhere within a radius of two or three yards, where they await a host. They attach themselves mainly to the head and neck of birds, and on mammals they are found on the head and ears. On heavily infested laboratory animals, however, they may be found in other places.

Engorgement usually requires four to seven days, though periods as short as two and one-half days and as long as 10 days have been observed. Records on the engorgement of 6364 larvae were made during the fall and winter of 1935–36. Larvae engorged on bobwhites in two and one-half to seven days with an average of 4.1 days. A total of 1201 larvae were engorged on this host with a maximum of 498 on one bird. The engorgement period on cotton rat, guinea pig and English sparrow was: minimum four days, maximum seven days, average about five days. A total of 1680 larvae were engorged on six juncos with a minimum period of four days, a maximum of 10 days, and an average of 5.4 days. The period of engorgement was practically the same on the meadowlark, pigeon, red-bellied woodpecker, roof rat and pine mouse (minimum three days, maximum seven days, and average about 4.5 days). Engorgement on white-footed mouse was slightly slower, minimum four days, maximum 10 days, average 5.9 days. Laboratory records show that the majority of engorged larvae leave the host during the night and early in the morning. After leaving the host, they have been observed to crawl between grass stems slightly above the ground, and there molting takes

place in one to three weeks. The shortest molting period recorded by Hooker, Bishopp & Wood (*2*) was seven days and the longest 121 days.

During September, October and November 1935, the larval molting period was recorded on 4892 individuals in the laboratory in Washington, D. C. The mean temperature during the first two months was about 75° F and during the last about 78° F. The molting period appeared to be somewhat longer in the case of larvae engorged on guinea pigs (minimum 13 days, maximum 27 days, average 15.8 days) and bobwhites (minimum 12 days, maximum 24 days, average 15.3 days) than in that of larvae engorged on English sparrows (minimum 12 days, maximum 16 days, average 12.2 days), pine mice (minimum 11 days, maximum 19 days, average 12.9 days), juncos (minimum 10 days, maximum 23 days, average 13.3 days), and white-footed mice (minimum 13 days, maximum 17 days, average 14.6 days). The larvae from the sparrows and juncos experienced the higher temperature mentioned above but those from the pine mice did not.

The longevity of unfed seed ticks ranges from about three months in summer to six months in winter. It is greatly reduced when the humidity is low.

THE NYMPH.—The elongate brown nymphs are ready to attach themselves to birds or animals about a week after molting. Engorgement usually requires four and one-half to seven days. One nymph dropped from a meadowlark 16.5 days after attachment. The average engorgement period among 137 nymphs on bobwhites, English sparrows, juncos and meadowlarks was 5.6 days.

Nymphs seek places for molting similar to those chosen by the larvae. Molting usually requires three to four weeks. The minimum period recorded among 40 nymphs observed in the laboratory in Washington, D. C., during October and December 1935 was 19 days among males and 21 days among females. The maximum was 28 days for both sexes. The average for the males was 22.3 days, and for the females 23.8 days. The proportion of the sexes was about equal. Hooker, Bishopp & Wood (*2*) record a minimum molting period, at an average temperature of 84° F, of 17 days and a maximum period, among ticks engorged in November, of 71 days. A molting period of 28 to 29 days was observed among nymphs collected on meadowlarks on November 19 and 20 at Valdosta, Ga.

The longevity of nymphs has not been fully determined, but it appears to be somewhat longer than that of the larvae.

Seasonal history.—While this tick may pass the winter in any stage, most overwintering individuals are in the larval and nymphal stages.

Our records show that few adults occur on animals in the spring. The earliest collection we have was taken from a wolf in Jackson county, Texas, on April 24, 1907. There is usually a rapid increase in the number of adults on livestock during July, and a peak is reached late in the summer or early in the fall. They appear later and disappear earlier in the northern edge of their range. A few specimens, mostly males, have been found on hosts after December 1. J. D. Mitchell collected a male on a dog on January 14, 1907, in Victoria county, Tex.

The accompanying chart, fig. 2, giving the number of screw worm cases on different dates reported as caused by the Gulf coast tick, is illustrative of the seasonal incidence of the adults.

In the fall the larvae and nymphs are abundant on birds, though the number declines rapidly after the middle of November, as is shown in table 1.

Nymphs may be found on hosts throughout the year.

Control measures.—Control of the Gulf coast tick is difficult because it occurs on various wild birds and animals as well as on livestock, because it does not remain long on any one host, and because, as is true of many species of ticks, it is very long lived.

Dipping.—It is obvious that dipping of livestock, as carried on against the cattle tick, will not eradicate the Gulf coast tick. Dipping all domes-

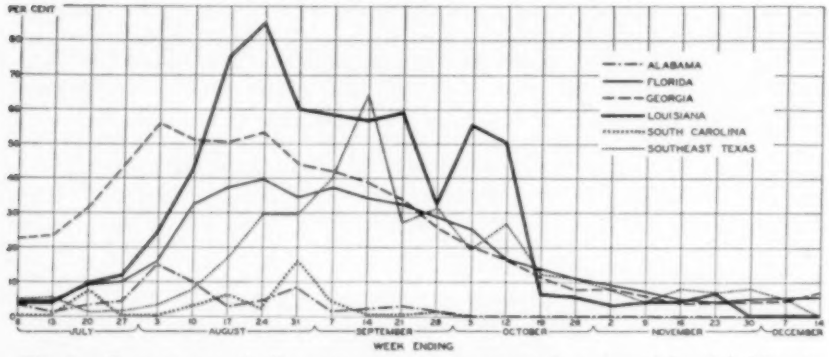

Fig. 2.—Percentages of all screw worm cases reported as caused by tick bites in southeastern Texas, Louisiana, Alabama, Florida, Georgia and South Carolina at weekly intervals from July 1 to December 14, 1935.

tic animals in a given area in an arsenical solution, as is done in cattle tick eradication, especially if the insides of the ears are thoroughly wet, will doubtless cut down its numbers. Where dipping is not being carried on against the cattle tick, it is not advisable to dip, because of the cost and the fact that some ticks in the ears are not killed.

Hand Dressing.—Light application of commercial pine-tar oil with a swab to the inside of each ear of all domestic animals at intervals of two weeks gives very satisfactory control. The same grade of pine-tar oil (sp. gr. 1.065, dehydrated) as is used for repelling screw worm flies is recommended. If screw worms are present in the tissues, benzol should be used before the pine-tar oil.

W. E. Dove and R. A. Roberts have used with success a mixture of 3 parts pine-tar oil and 1 part benzol; others use 3 parts pine-tar oil and 1 part cottonseed oil. Addition of the bland oil decreases the danger of burning but reduces duration of the repellent effect.

Only a small amount of the material should be used, and it should be applied thoroughly enough to cover every tick but not so freely that it will run down into the ear.

This treatment not only kills all ticks present but protects against reinfestation for 10 days to two weeks.

RANGE BURNING.—It is the common belief that burning over the ranges in winter controls the Gulf coast tick. Little definite experimental evidence on this question is yet available. Information thus far gained indicates that the majority of the ticks are in the seed tick or nymphal stage during the winter. A few of these are on birds, but apparently most of them are on the ground in an engorged condition or are unengorged and clinging to the grass or weeds awaiting a host. In pastures with scattered vegetation some ticks have a chance to escape because the entire area is not covered by the fire. Furthermore, the burned pastures become more or less restocked with ticks brought in on birds and other hosts.

CONTROL OF HOSTS.—To combat the Gulf coast tick, livestock should be kept where they can be treated with pine-tar oil regularly. The open-range grazing of stock as generally practiced over much of the coastal plain is very favorable to this pest. Wild hogs serve as hosts for many adults of this species as well as of other kinds of ticks and also of screw worms; hence their presence is detrimental to other livestock on the same range.

CLIMATIC CONTROL.—Reference has already been made to the restricted distribution of the Gulf coast tick apparently due to climatic conditions. That high humidity is favorable to this species is shown by the fact that when kept in a dry place the eggs usually shrivel and do not hatch and the ticks in the other stages live a relatively short time, whereas when eggs are kept on moist sand practically all of them hatch and the active stages live for many months.

The larvae and nymphs are fairly resistant to cold. In the laboratory several lots of 100 to 300 larvae were put in cloth-covered glass vials about 30 days after hatching. These vials were put in a refrigerator at room temperature and the temperature was gradually lowered during a period of three or four days to minima ranging in different tests from 15 to −9° F. When a desired minimum was reached, a vial would be put in a thermos bottle at refrigerator temperature and moved to room temperature. After 24 hours the vial was removed from the thermos bottle and put in a humidity box for observations on revival and longevity. The larvae survived well after being exposed to temperatures as low as −2° F, about half of them survived at −4° F, but all were killed when exposed to −6° F or lower. One lot exposed to 7° F and another exposed to −2° F were put on guinea pigs to compare their attachment and engorgement with ticks of the same age that had not been exposed to cold. The engorgement period was practically identical, but a much smaller number of the exposed larvae became engorged than in the check lot.

The exposure to low temperatures had an adverse effect on the longevity of most of the lots. During the first month after exposure there was no mortality in the test lots or checks. During the second month after exposure a noticeable mortality occurred in the lots exposed to temperatures of −2° F or lower, but none in lots exposed to 3° F or above, or

in the checks. During the third month after exposure there was a 10 per cent mortality in the checks and a much greater mortality in the test lots, but no close correlation between percentage of mortality and minimum temperature. During the fourth month after exposure the checks showed a mortality of 35 to 90 per cent, while the majority of the ticks in the test lots were dead.

Similar results were noted in the case of unengorged nymphs exposed to low temperatures. The effect on longevity was most marked in lots exposed to 0° F or lower.—9-21-36.

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THE SCREW WORM SITUATION IN 1935

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Screw worm, *Cochliomyia americana* C. & P., was probably more widespread during 1935 than ever before. The outbreak of the pest in the north central states is attributed to its dispersion from the southwest, where it was unusually abundant. The limited spread of this parasite in the southeastern part of the United States suggests that the program for control of screw worms was successful and that it checked disseminations of the pest.

In Florida and southern Texas the screw worm was active during mild weather throughout the winter. As spring advanced, it appeared in southern Georgia and over much of Texas. Early in June it was present in wounds of livestock in northern Georgia, in several counties in South Carolina, in southwestern Louisiana, throughout Texas and in some parts of Oklahoma.

Cases occurring before July 1, 1935.—In all of the southern states, large numbers of cases of screw worms occurred during the latter half of 1935. By segregating the records of cases experienced before July 1, we can visualize seasonal occurrences at different locations and can more fully understand some of the factors which contributed to the epizootic. Moreover, such a procedure seems to be helpful in evaluating results of the educational program for control of screw worms.

Texas.—Questionnaires received by H. M. Brundrett, of the Bureau of Entomology and Plant Quarantine, from 117 counties show that screw worms were active in many counties of Texas during the winter and that in southern Texas there was no complete cessation of activity. Hidalgo county in the lower Rio Grande valley reported that about 25

per cent of the usual number of cases occurring during summer were present during last winter. Other counties in southern Texas reported the following estimates of cases for last winter: Live Oak 200, Duval 200, LaSalle 5000, Frio 4000, Maverick 100, Uvalde 1500, Gillespie 500, Llano 5000, Mason 5000 and Menard 1000 cases. In the southern half of the state, cases of screw worms occurred among all classes of livestock during March. There was a decrease in the number of cases during the spring, but by June extensive and general rains occurred, producing conditions favorable to screw worm and blowfly breeding. The rains caused a delay in shearing, and when the sheep were finally shorn screw worm flies were abundant and ready to attack every shear cut. The carcasses of drowned animals developed tremendous numbers of blowflies and in some instances it was reported that such flies infested soil wool, causing extensive infestations of wool maggots. It was reported that every scratch and wound became infested with screw worms; also, that blowflies deposited literally hundreds of thousands of eggs on animals having screw worm infestations. Some stockmen reported that following infestations of screw worms the maggots from blowflies were responsible for completely devouring the animals.

During the last half of June, county screw worm supervisors reported 762 cases of screw worms from 18 counties of southeastern Texas. At this time, reports of county agents indicated that infestations were also present in the northern and eastern counties of the state. Many reported winter activity of screw worms in both of these areas.

Arizona and California.—In Arizona and in southern California and northward along the San Joaquin valley of California, screw worms were present during the early part of 1935. In the vicinity of Oakdale, Calif., they gained a foothold when lambs were brought from the southwest for fattening on Ladino clover. Such animals were shorn shortly after they arrived in California and the shear cuts were responsible for many cases of screw worms. Numerous infestations in the navels of newly born calves about dairies were reported.

Florida.—From questionnaires received from county agents, Dr. W. V. King obtained estimates of screw worm cases after the cold waves of December and January. He reports that during January, February and March 1935, 7250 cases of screw worms were estimated to have occurred in 27 counties of the state. The following are the monthly estimates: for January 2633, for February 1268 and for March 3349. During this period screw worm cases occurred as far south as Lake Okeechobee, and numbers were reported in counties having the greater numbers of cattle. At Apalachicola minimum temperatures of 24° F were experienced from January 22 to 25, but this freeze did not stop the activity of screw worms. Calhoun county reported 30 cases for January, 407 for February and 25 for March. From various counties in Florida Dr. King obtained specimens, and from 18 infestations the larvae were identified as *C. americana*. One lot of larvae was identified as *Phormia regina* Meig. Some of the Florida cases occurring during January were found near the Georgia-Florida boundary line.

Georgia.—The cold waves of December 11 and 12, 1934, and of

January 20 to 29, 1935, were not sufficient to kill all screw worms in Georgia. In January Macon experienced 22° F, and Thomasville 20° F. Following these freezes an occasional case of what was thought to be screw worms was reported in castration wounds. The first authentic case came to our attention at Hinesville on April 15, 1935. During 1934 the first case was observed in this locality on May 15. Records obtained during the last week in June show that 784 cases of screw worms occurred in 71 different counties of the state. These cases were distributed in the same counties and in about the same proportion as were the infestations reported throughout the year. During the last week in June, as many as 86 cases were found in Thomas county. On June 20, specimens obtained from the foot of a horse in Walker county were identified by E. C. Cushing as *C. americana*. From records obtained from county supervisors it was learned that screw worms were well distributed over the state before July 1 and it seemed reasonable to believe that another serious outbreak of screw worms might be expected.

South Carolina.—In South Carolina, at Charleston, a minimum of 28° F was recorded on January 25 and 22° on January 28. During the period January 26 to June 1, 1935, 35 screw worm or maggot infestations of livestock were reported from 14 counties of the state. In addition to these, 45 cases were reported during the month of June. These infestations extended from the extreme southern portion northward to New Berry, Richland, and Clarendon counties. The distribution coincided closely with the known occurrence of the pest during 1934. The counties reporting cases before July 1 were the ones giving a high incidence during the last half of the year.

Louisiana, Mississippi and Alabama.—On December 11 and 12, 1934, a cold wave and a 20° minimum temperature were experienced in central Louisiana, Mississippi and Alabama. On January 20 to 29, 1935, a second cold wave visited these areas. At this time Birmingham, Ala., experienced 14° F and Meridian, Miss., 16° F on three consecutive days. Early cases of screw worms were not reported for either of these localities, or for any places north of them.

During the latter half of June supervisors of screw worm control reported 176 cases from southern Louisiana, 158 cases from southern Mississippi, and 144 cases from southern Alabama. Since specimens from wounds were not obtained during the spring and early summer, the extent to which the true screw worm was involved is not known. The control work carried out during the autumn of 1934 in Mississippi under the supervision of D. C. Parman informed the farmers on methods of prevention and treatment and supplied them with small quantities of materials for the treatment of animals. Screw worm and blowfly populations were reduced to a low point.

Educational program to control screw worms.—An educational program for control of screw worms in the southeastern states and in 19 counties of southeastern Texas aided in (1) preventing spread of the pest, (2) giving a high degree of control and a low death rate, (3) encouraging the use of better methods of animal management, and (4) obtaining data on preventable injuries which induced infestations in animals.

In 316 counties experiencing cases of screw worms and in advance of the zone infested by this pest, 9255 meetings and demonstrations were attended by 173,714 farmers and stockmen. In addition, county supervisors interviewed, instructed or demonstrated to 372,830 stock owners on their farms. During 127 exhibits at fairs, it is estimated that 916,456 persons viewed the displays and received instructions on screw worm control. Records kept by screw worm supervisors show that 103,434 circulars and bulletins were distributed and that large numbers of these were reprinted and distributed by county agents and agricultural teachers. Records show that 11,453 posters were nailed in conspicuous places where they were not exposed to the fading effects of sunlight and rain. In Mississippi and Louisiana 55,000 handbills urging prompt treatment of infested animals were distributed among farmers. News items were received from 945 daily and weekly newspapers. In southern Georgia, in cooperation with the Bureau of Animal Industry, 442 pens and chutes were constructed for community use. In Florida 144 such units were built in cooperation with the State Works Progress Administration. For treatment of infested animals, 40,860 gallons of pine-tar oil and 42,143 gallons of benzol were distributed to farmers.

Between July 1 and December 15, 242,502 cases of screw worms were reported in the southeast. Approximately seven-eighths of these infestations occurred in cattle and hogs. More than one-half of all cases occurred in uncontrolled hogs in the woods and in hogs on farms.

The injuries causing the screw worm infestations group themselves naturally into five major classifications, accounting for 224,172 of the reported cases. Bites of the Gulf Coast tick, *Amblyomma maculatum* K., resulted in 49,581 cases; surgical operations including castrations, dehorning, marking and branding, caused 56,145 cases; the navels of newly born animals furnished sites for 37,433 cases; injuries caused by goring or "snags and scratches" gave 55,422 cases; and the bites occasioned by catch dogs and fighting hogs were responsible for 25,591 cases. Minor and unclassified injuries of various types caused 8206 infestations. It is seen that most of the cases represent injuries which need to be prevented by better methods of handling animals.

Other than a low incidence of cases and a low mortality of infested animals, concrete examples of benefits derived from the educational program include the following:

(1) The checking of spread of screw worms from the southeastern states to more northern areas. The pest occurred over most of Georgia and South Carolina during the early part of the season, but only a few cases could be found in North Carolina and the lower Tennessee valley. There was no extensive spread of the pest.

(2) Following complete destruction of screw worms in Mississippi, southeastern Louisiana and western Alabama during the winter, reintroductions at Meridian and Utica, Miss., were promptly eradicated and reinvasion of the free area in Louisiana and Alabama was greatly retarded and did not become complete during 1935.

(3) A spectacular control of screw worms in sheep was obtained when sheep owners were brought to a realization that it was absolutely neces-

sary to herd the animals and apply pine-tar oil for both ticks and screw worms. The control of the ticks also improved the condition of the animals.

(4) Tipping of horns is reducing cases resulting from gores and preventing screw worm infestations which often occur following dehorning. Horn tipping is also making the cattle more salable for feeders.

(5) Camden county, Georgia, one of the unfenced frontier counties, obtained almost complete control of screw worms by systematic examination and treatment of range animals.

(6) Uncontrolled hogs in unfenced woods are now recognized as the principal reservoir for screw worm infestations in the southeastern states, and gradually some counties are taking steps to obtain control of or to eliminate such animals.

(7) The program has shown that the human element and age-old customs are factors which are successfully combated only through the bitter and costly school of experience. The practice of marking and castrating hogs and cattle before turning them into peanut and bean fields stand out like a sore finger on the hand of screw worm control.

(8) Many of the practices necessary in effectively fighting the screw worm are recognized as very desirable practices and their adoption has been materially accelerated by this program. Some of these practices are the introduction of better-bred livestock, including polled bulls, better care of animals, provision and use of supplemental feeds, development of better pastures and construction of silos.

(9) As a result of this campaign many stock owners have been brought to a realization that the screw worm can be controlled and a more receptive and cooperative attitude has been developed among them.

Cases occurring from July 1 to December 15, 1935.—From 297 counties of the six southeastern states, and from 19 counties of southeastern Texas, 242,502 cases of screw worms were reported by county screw worm supervisors for the period July 1 to December 15. A total livestock population of 9,722,236 animals was recorded for 1935 by the U. S. Bureau of Census in this area. Using such figures as a basis, an average of 2.49 per cent of all domestic animals were infested with screw worms.

The following is the number of reported screw worm cases and the percentage of infestation based on the total livestock (census figures) in each state: Texas (19 southeastern counties) 14,705 or 1.65 per cent, Louisiana 9895 or .72 per cent, Mississippi 219 or .02 per cent, Alabama 9380 or .63 per cent, Georgia 74,956 or 2.96 per cent, Florida 126,959 or 10.08 per cent, South Carolina 6388 or .58 per cent.

Animals Dying from Screw Worm Infestations.—In 297 counties of the six southeastern states, and in 19 counties of southeastern Texas, there were 5215 deaths of animals among 242,502 infestations of screw worms, or an average mortality rate of 2.15 per cent. The dead animals were valued at $23,311.75. The highest mortality noted was in Florida—3.37 per cent. These figures are in marked contrast to the estimated mortality in Georgia for 1934, which amounted to 12.4 per cent of all livestock. Since animals die of screw worms only from neglect or mis-

treatment of wounds, we must conclude that during the control program infested animals were promptly and properly treated with a high degree of efficiency.

During 1934, Dove & Parman (*1*) estimated that 12 per cent of all animals in Georgia were infested with screw worms, while King & Bradley (*2*) in Florida, Robinson (*4*) in Alabama, and Laake (*3*) in Louisiana and southeastern Texas, made estimates which agree closely with those obtained for Georgia. When these estimates for 1934 are compared with reports of infestations by screw worm supervisors during 1935, we can conclude only that the educational program gave a high degree of control for screw worms.

Need for further control.—In attempting to obtain a mortality lower than that reported for the control program, we are forcibly impressed by farmers and stockmen that it is not possible to treat uncontrolled hogs in the woods. These animals constitute a large reservoir for infestations of screw worms in the southeastern states and the problem resolves itself largely into prevention of infestation in such animals. Prevention of screw worms and kidney worms in hogs is more easily accomplished when the animals are kept in fenced pastures.

Even under fenced conditions, castrated or earmarked hogs should be kept in pens and treated daily with pine-tar oil until the injuries are healed. Sows bringing two litters of pigs during each year necessarily drop one litter when screw worm flies are present. These animals need applications of pine-tar oil about the vulva before the pigs arrive and again after the pigs are born. The navel of each pig should be treated with light applications of pine-tar oil until the cords become dry and the openings are healed.

Control of screw worms in cattle in the southeastern states is not as difficult as it is in uncontrolled hogs because it is possible to use community stock pens for the handling and treatment of cattle on the open range. Also, it is less difficult to practice some of the good principles advocated by animal husbandmen. Some of these include (1) use of pincer type emasculators on undesirable sires, (2) replacing poor sires with pure-blood animals, (3) controlled breeding so that calves will arrive during the winter when screw worm flies are inactive or when they are least active, (4) avoiding the use of catch dogs, whips and stiff ropes, (5) improving the pasturage, (6) disposal of inferior heifers for slaughter and separation of yearling heifers from the herd to prevent breeding, (7) confining breeding bulls in pens and feeding them during the winter, and (8) growing ensilage, hays and roughages for winter feeds. The adoption of these practices will require a period of years but eventually good screw worm control will accompany the development of a more profitable livestock industry in the southeastern states.

The need for further control of screw worms in other domestic animals is not as marked as it is in cattle and hogs. When good control is obtained among these two species of animals we can expect less trouble among other kinds of domestic animals and among wildlife. The application of good fundamental principles which prevent injuries is applicable to all kinds of animals.

Table 1.—Screw worm cases due to major predisposing causes, control area, 1935.*

Period	Causes of Screw Worm Cases											
	Tick Bites		Surgical Operations		Birth of Young		Snags and Scratches		Dog and Hog Bites		Total Cases Due to Major Causes	
	number	*per cent*	*number*	*per cent*	*number*	*per cent*	*number*	*per cent*	*number*	*per cent*	*number*	*per cent*
July 1–27	3,928	1.62	6,401	2.64	9,274	3.82	6,984	2.88	2,724	1.12	29,311	12.08
July 28–Aug. 24	16,483	6.8	5,575	2.3	6,624	2.73	8,774	3.62	3,883	1.6	41,339	17.05
Aug. 25–Sept. 21	16,951	6.99	6,254	2.58	4,495	1.85	9,649	3.98	5,223	2.15	42,572	17.56
Sept. 22–Oct. 19	7,479	3.08	10,569	4.36	4,529	1.87	9,319	3.84	4,427	1.83	36,323	14.98
Oct. 20–Nov. 16	3,677	1.52	19,602	8.08	8,390	3.46	13,707	5.65	6,226	2.57	51,602	21.28
Nov. 17–Dec. 14	1,063	.44	7,744	3.19	4,121	1.7	6,989	2.88	3,108	1.28	23,025	9.49
Total	*49,581*	*20.45*	*56,145*	*23.15*	*37,433*	*15.43*	*55,422*	*22.85*	*25,591*	*10.55*	*224,172*	*92.43*

* Total number of cases from major and minor causes, July 1 to December 14, 1935, 242, 502.

Table 2.—Incidence of mortality and mortality due to screw worms in livestock in 96 counties of Texas in 1935.

Kind of Livestock	No. at U. S. Census*	No. Cases Reported	Per Cent Infested	No. Infested Animals Dying	Per Cent Infested Animals Dying	Total Value Reported	Average Value of Each
Cattle	2,425,957	544,915	22.46	38,615	7.09	$504,572	$13.07
Hogs	452,618	42,316	9.35	5,593	13.22	33,019	5.90
Horses	253,786	25,088	9.89	750	2.99	32,986	43.98
Mules	356,981	12,552	3.52	434	3.46	25,090	57.81
Goats	1,108,332	157,818	14.24	32,172	20.39	66,190	2.06
Sheep	2,140,308	425,493	19.88	100,199	23.55	482,192	4.81
Others		1,935		433	22.38	745	1.72
Total	*6,737,982*	*1,210,117*	*17.96*	*178,196*	*14.73*	*$1,144,794*	

* Census figures of 1930.

PREDISPOSING CAUSES OF INFESTATION.—Table 1 gives the five major types of injuries responsible for 224,172 of the 242,502 screw worm infestations reported in the control area from July 1 to December 14, 1935. For comparative studies the figures are grouped in periods of four weeks. It will be observed that the greatest number of screw worm cases occurred during the period October 20 to November 16.

Screw worms in Texas.—Questionnaires on screw worms were received from 96 county agricultural agents of Texas by Mr. H. M. Brundrett of the Bureau of Entomology and Plant Quarantine, see table 2. The estimates obtained by him through the Extension Service show that among 6,737,982 animals (U. S. Census 1930) there were 1,210,117 cases of screw worms, or an average infestation of 17.96 per cent. The estimated expenditures for control of these cases amounted to $987,050, or an average of about 82 cents per treated animal. These figures if applied to the livestock population (Yearbook 1935) of 18,208,000, would give 3,248,688 cases of screw worms with a cost of $2,663,924 for labor and treatment. The above estimate of the cost of treating an infested animal is very conservative as our records indicate a much higher figure. From 96 counties it was estimated that 178,196 among 1,210,117 animals, or 14.73 per cent of the infested animals, died of screw worms. These animals had an estimated value of $1,144,794. In applying the average values of these estimates and the present mortality of infested animals to the estimated infestations of the state, it is figured that the animals dying of screw worms had an estimated value of $3,140,439. Adding the estimated costs of treatment, the losses amounted to $5,804,363. This estimate does not take into consideration the infestations in game, or the decreased values of animals recovering from the infestations, or the added cost of riders used in hunting for infested animals. It is not possible to obtain such figures, but it seems not too much to estimate the total loss in Texas for 1935 at 10 million dollars.

The great abundance of flies and of screw worm cases in Texas and other parts of the southwest, coupled with increased shipments of stock during the summer to the pastures and feed lots of the north, extended the trouble into many of the north central states. In much of this territory the farmers were not familiar with the pest and even though they noted animals with infested wounds when they were unloaded, nothing was done until the larvae had dropped out, thus infesting new areas. Before the seriousness of the situation was discovered and a veterinarian called, often many animals had been killed. From these local foci the flies spread by flight and by local movement of stock so that whole counties or groups of counties became infested. The community trading centers were especially conducive to the spread of the pest. In some cases animals were brought in for sale or trade because they were infested. The people were often in ignorance of means of successfully treating the infestations and the infested animals were discounted from 10 to 25 per cent and traded frequently, thus accelerating the spread.

Dispersion from Texas.—Information gained from a questionnaire sent out by Dr. W. L. Black of the New Mexico Extension Service indicates a 2.4 per cent infestation in that state. O. G. Babcock, who did

some survey work in Oklahoma, estimated that there was a 10 to 15 per cent infestation in the south central part of that state.

In the Pike and Sagamon county areas in Illinois, W. J. Spicer reported 3805 cases and 311 deaths of animals from 13 infested counties. The pest first occurred during August and following receipt of shipments of sheep from Texas.

Information obtained by personal inquiry and by questionnaires sent to veterinarians and county agents shows many counties in Kansas to have had 1000 to 2000 infested animals. Several counties in Indiana, Iowa, Missouri, Kentucky and Nebraska were infested, as shown in the map, fig. 1. In the northern states the losses were accentuated by the fact that many of the cases were among very high-grade animals.

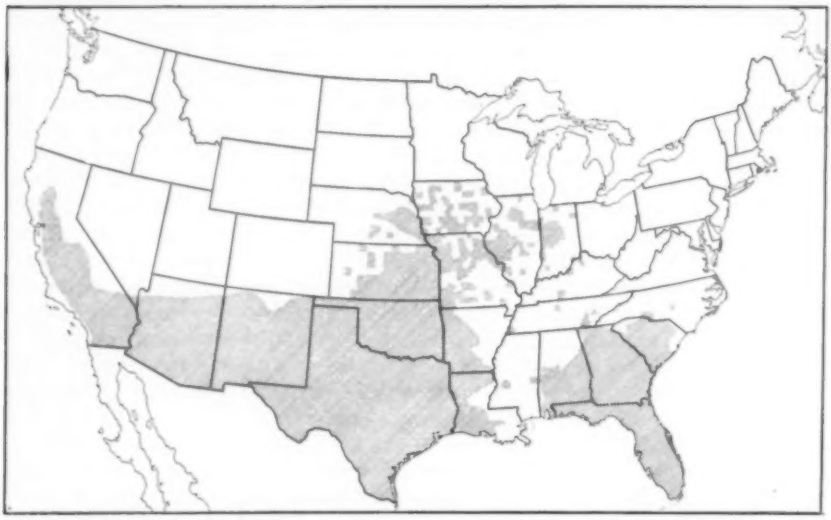

Fig. 1.—Distribution of screw worm, *Cochliomyia americana*, 1935.

Conclusions.—The occurrence of cases of screw worms during winter in Florida and southern Texas suggests that a most intensive program for control of screw worms should be conducted in these areas, especially during the winter.

The incidence of screw worm cases of only 2.49 per cent, the mortality of infested animals of only 2.15 per cent, and the lack of extensive spread of screw worms from the widely distributed cases which occurred prior to July 1, show that efficient results were obtained from the screw worm-control program.

The incidence of screw worm cases of 17.96 per cent and the mortality of 14.73 per cent of the infested animals in the counties outside the control area, as well as the widespread disseminations of screw worms to the north central states from the southwestern states, show a distinct need for intensive work in screw worm control in southern Texas and for some method of checking the movement of screw worm-infested animals into uninfested territory.

The large percentage of screw worm cases induced by factors which are controllable by man indicates that with a more complete adoption of the recommendations for control a further reduction of losses may be expected.—9-21-36.

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PILOSITY OF THE COTTON PLANT

IN RELATION TO ADHERENCE OF DUSTED CALCIUM ARSENATE

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For many years calcium arsenate dust has been widely accepted as the standard insecticide for the control of the boll weevil and the cotton leaf worm. The extent to which this dust adheres to the various types of plants has not been known, and little work has been done to determine this. Work conducted along this line by W. S. Cook and F. H. Tucker in 1924, 1925 and 1926 (unpublished reports) gave inconsistent results. With a view of eliminating some of the variables which these workers encountered, it was decided that the writer should continue this investigation.

Experimental methods used.—During the season of 1934 pilosity was studied on 75 varieties of cotton, some of which were grown under several sets of conditions. The hairs were counted on 1710 square millimeters of surface on the various parts of plants of each variety. Under the many sets of conditions it was found that pilosity was a fairly stable character.

Varieties Stoneville 4–96 and Suttle were grown under identical conditions at Poplarville, Raymond and Stoneville, Miss. The former was found to be very pilose and the latter very smooth. The composite average number of hairs for 1710 square millimeters of surface was found to be 8358, or an average of 4.89 hairs per square millimeter on Stoneville 4–96, while on Suttle the composite average number of hairs for an equal surface dropped to 949, or an average of .55 per square millimeter.

In the spring of 1935, two one-tenth-acre plots at Stoneville were seeded with the two above-named varieties. The rows were alternated throughout both plots. On July 28, when the plant heights for Stoneville 4–96 and Suttle averaged 37.98 and 41.55 inches respectively, one plot was dusted with calcium arsenate. The application was made at 6 a. m. when the plants were thoroughly wet with dew. The dust was applied with a double-nozzle hand gun, calibrated to distribute 10 pounds per acre. Since the rows alternated, each nozzle dusted one row of each

variety at every round while going over the plot the first time. When the entire plot had been dusted, a second application was made at the same rate but in reverse order, thereby permitting each nozzle to dust each row once. This method eliminated the variation caused by a decrease in the amount of dust delivery from the gun as the hopper load diminished, and at the same time eliminated any variation that could come from individual nozzles.

When the application was completed, a total of 20 pounds of calcium arsenate per acre had been distributed. This excessive amount made it possible to detect each leaf which had full exposure at the time of application.

Fig. 1.—Side view of leaf cutter.

A leaf cutter was constructed by cutting down the depth of the body and the top of an aluminum soil-sample can. The depth of each part was about one-eighth inch. The edges were sharpened scissors fashion. These pieces were then riveted to the inner jaws of a cast-aluminum lemon squeezer, fig. 1.

Two hours after the dust was applied, 500 disks $2\frac{1}{2}$ inches in diameter, were cut from the leaves of each variety by means of this cutter, which made it possible to remove clean-cut areas of definite size from the leaves of undisturbed plants.

These samples were placed in acid-resisting buckets and individually washed in 1 liter of 5 per cent solution of nitric acid. Three days later a second sampling was made and treated likewise.

On August 9, at 10 a.m., when cotton plants were thoroughly dry, the entire experiment was repeated on a fresh plot of cotton in order to eliminate any error possible through absorption or retention of previous dust.

All solutions were preserved in glass jars and forwarded to F. H. Tucker, chemist at the Bureau of Entomology and Plant Quarantine laboratory at State College, Miss., to whom thanks are due for making the analyses.

Results.—The amount and the comparative percentage of arsenic as arsenic pentoxide (AS_2O_5) adhering to the plants of the smooth and pilose varieties two hours and three days after the cotton had been dusted, when wet and when dry, are shown in table 1.

It is interesting to note that variety Stoneville 4–96, the more pilose, retained more arsenic pentoxide than Suttle under all comparable conditions. Special attention should be called to the much smaller amount of arsenic pentoxide found when the plants had been dusted dry. Two hours after being dusted dry, Stoneville 4–96 retained only 27.06 per cent as much arsenic as when dusted wet, and Suttle retained only 19.63 per cent as much as when dusted wet.

Table 1.—Comparison of adherence of calcium arsenate to a hairy (Stoneville 4–96) and a smooth (Suttle) variety of cotton when applied under wet and dry conditions, Stoneville, Miss., 1935.

Condition of Plants When Dusted	Time Between Dusting and Sampling	Milligrams AS_2O_5 Found per 100 Disks*	Percentage of Amount 2 Hours After Wet Application	Percentage of Amount on Suttle as Compared with Stoneville 4–96
		Stoneville 4–96 (Hairy)		
Wet	2 hours	377	100	
	3 days	233	61	
Dry	2 hours	102	27.06	
	3 days	58	15.38	
		Suttle (Smooth)		
Wet	2 hours	321	100	85.15
	3 days	205	63.86	87.99
Dry	2 hours	63	19.63	61.76
	3 days	38	11.84	65.52

* Area of sample 490.87 square inches.

Summary.—Of the two varieties of cotton under test in calcium arsenate-dusting experiments in 1935 at Stoneville, Miss., the more pilose retained more arsenic pentoxide under all like conditions.

The smooth variety when dusted wet retained more poison than the hairy variety when dusted dry.

When dust applications were made on dry plants, the percentage retained, as calculated on the basis of the wet applications, remained greater for the hairy variety than for the smooth.

The percentage of adherence for the smooth variety under both dates of sampling, as calculated on the basis of the hairy variety, was significantly greater when plants were dusted wet.

These data offer strong evidence that pilosity is an important factor in the adherence of calcium arsenate. This character is more important when plants are dusted dry.—6-22-36.

THE VIRGINIA state entomologist announces that the European corn borer has recently become established in the counties of Princess Anne, Norfolk and Elizabeth City, Va., and that intrastate quarantine regulations have been revised accordingly. The borer was formerly known to exist only in Accomac and Northampton counties, Va.

EXPERIMENTS WITH NEW MATERIALS TO CONTROL PEACH BORER

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Extensive experiments with the emulsion of crude cottonseed oil impregnated with paradichlorobenzene for control of peach borer, *Conopia exitiosa* (Say), in nursery stock and in orchard peach trees of all ages have been conducted at Fort Valley, Ga., during the last four years. The results of these experiments verify the conclusions reported when this new method of peach borer control was announced (*1*), namely, that paradichlorobenzene–crude cottonseed-oil emulsion applied as a spray is not so toxic to peach trees as paradichlorobenzene crystals, and that it has been the only safe means of controlling the peach borer in 1, 2 and 3-year-old peach trees under conditions in the south. The spray is an improvement over the paradichlorobenzene crystal treatment in that it is easier to apply and requires less time for application. Furthermore, it is as effective as the crystals, it is effective above the ground line in some cases, less of the active ingredient is required, and good borer control can be obtained later in the season because of the rapidity of the action from it.

Materials tested.—Of the new materials recently tested for the control of the peach borer, ethylene dichloride emulsion has received the most attention. Considerable experimentation with that material has been in progress at Fort Valley during the last three years, and the results warrant an announcement in regard to it at this time.

Ethylene dichloride emulsion is made by stirring 9 parts (by volume) of ethylene dichloride into 1 part of potash fish-oil soap (containing approximately 30 per cent of soap and 70 per cent of water) and diluting to the required strength.

Ethylene dichloride emulsion gave the best borer control and proved to be the safest, under the conditions in the fall of 1935, of all the materials used in the experiments dealing with orchard trees of all ages and with nursery stock before it is dug. Although the borer control from the emulsion of crude cottonseed oil impregnated with paradichlorobenzene was practically as good this season as that from the crystals, it was not so good as that of other years, which in all probability was due to the fact that drought and unusually warm weather caused rapid diffusion of the paradichlorobenzene gas through the very dry soil to such an extent that it did not reach the bottom of the main root or was too weak when it did reach that point to kill the borers there. This assumption is supported by the fact that live borers were found on the bottom of the main root of a number of trees, whereas all borers on the sides of the root closer to the ground line were dead. The emulsion of crude cottonseed oil impregnated with paradichlorobenzene was not so toxic to the trees as paradichlorobenzene crystals, but ethylene dichloride emulsion was safer than either of these materials.

At 9.44 cents per pound for ethylene dichloride (1 gallon = 9 pounds)

and 5 cents per pound for potash fish-oil soap, the ethylene dichloride emulsion for treating 100 3-year-old orchard trees would cost 55.5 cents. At the present price of 75 cents per gallon for crude cottonseed oil (an increase of 50 per cent over the price in 1934), 20 cents per pound for paradichlorobenzene crystals, and 5 cents per pound for potash fish-oil soap, the emulsion of crude cottonseed oil impregnated with paradichlorobenzene for treating 100 3-year-old orchard trees would cost 94 cents. The paradichlorbenzene crystal treatment is not recommended for control of the peach borer in 3-year-old orchard trees under conditions in the south on account of the danger of tree injury; if it were used, the crystals for treating 100 trees of that age with the half-ounce dose would cost 62.5 cents.

Results from ethylene dichloride emulsion.—The most important results from the ethylene dichloride treatment applied on October 21 or 22, 1935, are as follows: One-fourth pint of 4 per cent emulsion per tree gave 100 per cent control of the borer in nursery stock, with no tree injury. Previous experiments with dug peach nursery stock resulted in the conclusion that 4 per cent ethylene dichloride emulsion sprayed on the soil around the stock, heeled in an upright position, at the rate of 1 quart to each bundle of 15 trees, will eliminate practically all peach borer larvae without injuring the trees if the application is made during the dormant season before any growth whatever starts. The soil should be allowed to settle or should be packed around the heeled trees before it is sprayed, and the soil should also be dry before treatment. Severe injury to the root system may result if the emulsion is applied to loose soil around heeled nursery stock, which permits ready seepage of the spray to the tender root system. One-fourth pint of 10 per cent emulsion gave 85.7 per cent control of the borer in 1-year-old orchard trees, with no tree injury. One-half pint of 5 per cent emulsion gave 100 per cent control of the borer in 2-year-old orchard trees, with no tree injury. One-half pint of 10 per cent emulsion gave 100 per cent control of the borer in 3-year-old orchard trees, with no tree injury. One-half pint of 15 per cent emulsion gave 85 per cent control of the borer in 4-year-old trees, with no injury to six trees and injury into the cambium at three small spots on the side of an old borer wound on one tree. One-half pint of 15 per cent emulsion gave 92 per cent control of the borer in 5-year-old trees, with no injury to six trees and doubtful injury into the cambium at one place on one tree. One-half pint of 20 per cent emulsion gave 100 per cent control of the borer in 6-year-old trees, with no tree injury. Practically the same results were obtained from experiments conducted in the fall of 1934.

Results from an emulsion of crude cottonseed oil impregnated with paradichlorobenzene.—The most important results from the emulsion of crude cottonseed oil impregnated with paradichlorobenzene applied last fall are as follows: One-fourth pint of that emulsion carrying one-eighth ounce of paradichlorobenzene to each tree on October 11 gave 100 per cent control of the borer in nursery stock, with no injury to six trees and a few flecks into the cambium of four trees. One-fourth pint of the emulsion carrying one-fourth ounce of the chemical to each tree on October 22 gave 66.7 per cent control of the borer in 1-year-old orchard

trees, with no tree injury. One-half pint of the emulsion carrying one-fourth ounce of the chemical to each tree on October 22 gave 100 per cent control of the borer in 2 and 3-year-old orchard trees, with no tree injury. One-half pint of the emulsion carrying one-half ounce of the chemical to each tree on October 10 gave 58.7 per cent control of the borer in 4-year-old trees, with no injury to 19 trees and one small spot into the cambium of one tree. That dosage applied on October 21 gave 80.8 per cent control of the borer in 5-year-old trees, with no injury to 18 trees and one small spot into the cambium of one tree. One pint of the emulsion carrying three-fourths ounce of the chemical to each tree on October 21 gave 100 per cent control of the borer in 6-year-old trees, with no injury to 19 trees and a few flecks in the bark layers only at one small place on one tree.

The 4-year-old orchard was more heavily infested with peach borers than the other orchards used for the experiments, and this caused masses of gum and frass around most of these trees which, as a result of the drought, formed a hard cake that sealed many borer galleries. There was also considerable dry gum and frass from the previous season's infestation around a number of the 4-year-old trees. No doubt this interfered with the circulation of gas and probably accounts for the poorer borer control from the materials used around the 4-year-old trees.

Results from paradichlorobenzene crystals.—The most important results from the paradichlorobenzene crystal treatment last fall were as follows: One-eighth ounce per tree applied October 22 gave 14.3 per cent control of the borer in nursery stock, with no tree injury, but that dosage applied October 11 killed one tree and very severely injured into the cambium two other trees out of the five treated. One-fourth ounce per tree applied October 22 gave 66.7 per cent control of the borer in 1-year-old orchard trees and severely injured into the cambium two of the five trees treated. One-fourth ounce per tree applied October 11 severely injured into the cambium one of five 2-year-old orchard trees. There was only one dead borer in these trees. The mounds around the 2-year-old trees that received the same dosage on October 22 were opened six days after treatment on account of the danger of tree injury, which had started on one tree at that time. One-half ounce per tree applied October 22 to 3-year-old trees so severely injured one tree into the cambium that it may die. Of the other four 3-year-old trees that received one-half ounce of the crystals per tree, three were severely flecked into the cambium and one was moderately flecked in the bark layers. Three-fourths ounce per tree applied October 21 gave 92.3 per cent control of the borer in 4-year-old trees but caused severe injury into the cambium at one place on one tree and severe injury in the bark layers of one tree, with no injury to three trees. The same treatment gave 100 per cent control of the borer in 5-year-old trees, with moderate flecking in the bark layers of one tree and no injury to four trees. One ounce of paradichlorobenzene crystals per tree applied October 21 gave 100 per cent control of the borer in 6-year-old trees. Of the five trees receiving that treatment, two were severely injured into the cambium and three were severely injured in the bark layers.

Other materials tested.—Experiments conducted last fall show that an emulsion of amylene dichlorides is very toxic to peach nursery stock and orchard trees when used at concentrations sufficient to give only fair control of the peach borer. This material may prove to be of value to workers eradicating plant diseases, where a cheap material is needed to kill diseased trees. An emulsion of mixed amyl chlorides was neither effective against the peach borer in nursery stock and orchard peach trees nor toxic to the trees at the same concentrations as used for the amylene dichlorides emulsion.

Discussion of results.—Results of these experiments are conclusive evidence that under the same weather and other conditions, paradichlorobenzene crystals are much more toxic to peach trees than the emulsion of crude cottonseed oil impregnated with paradichlorobenzene. On account of the danger of severe tree injury, paradichlorobenzene crystals should not be used around peach trees less than 4 years of age under conditions in the south.

The average number of borers found in the untreated trees was considerably higher than that found in the treated trees. This is proof that many tiny borers were killed by the treatments and decomposed to the extent that they could not be found when the trees were examined for results. Therefore, the percentage of control recorded for the several treatments is undoubtedly lower than was actually obtained. Judging from the number of tiny borers found in the untreated trees at the time the results of the experiments were recorded, a number of eggs on the treated trees were probably destroyed by the materials at the time they were applied.

The results of the experiments in 1935 show that the applications made during the period October 20–25 were more effective and in some cases safer than those made during the period October 10–15, the time now recommended for peach borer-control applications in this latitude. The later applications gave better borer control from all the materials used last season, including paradichlorobenzene crystals. Observations made in 1933 and 1934 indicated that the period October 10–15 for applying paradichlorobenzene for peach borer control in this latitude, as now recommended, is a little too early for the treatment under conditions in central Georgia. Oviposition studies showed that in both 1933 and 1934 a few eggs were deposited after that period, and this resulted in several live borers being found in trees from which all borers had been eliminated between October 10 and 15. On the basis of these observations, verified by the results of experiments in 1935, it is recommended that the dates for treating peach trees for the control of the peach borer in central Georgia and similar latitudes be changed from October 10–15 to October 20–25.

Summary.—Ethylene dichloride emulsion gave the best borer control, was the cheapest, and proved to be the safest, under the conditions in the fall of 1935, of all the materials used in the experiments dealing with orchard trees of all ages and with nursery stock before it is dug.

Under the same weather and other conditions, paradichlorobenzene crystals are much more toxic to peach trees than the emulsion of crude

cottonseed oil impregnated with paradichlorobenzene. On account of the danger of severe tree injury, paradichlorobenzene crystals should not be used around peach trees less than 4 years of age under conditions in the south.

An emulsion of amylene dichlorides is very toxic to peach nursery stock and orchard trees when used at concentrations sufficient to give only fair control of the peach borer. An emulsion of mixed amyl chlorides was neither effective against the peach borer in nursery stock and orchard trees nor toxic to the trees at the same concentrations as used for the amylene dichlorides emulsion.

Applications made during the period October 20–25 were more effective and in some cases safer than those made during the period October 10–15, the time now recommended for peach borer-control applications in this latitude.—10-23-36.

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FURTHER STUDIES ON COTTON-ROOT APHID

AND OTHER SUBTERRANEAN APHIDS IN SOUTH ATLANTIC STATES

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In a previous article (Jour. Econ. Ent. 28(5): 755–60), three species of subterranean aphids, *Anuraphis maidi-radicis* Forbes, *Trifidaphis phaseoli* (Pass.) and *Rhopalosiphum* sp., found attacking the roots of cotton in South Carolina, were discussed as to damage, distribution and biology. Investigations throughout 1935 have added considerably to each of the phases discussed previously, and have also furnished information on other subterranean species not found attacking cotton.

In the spring of 1935 a survey was made to determine the distribution and amount of damage caused by subterranean aphids to cotton in the south Atlantic states, from northern Florida to southeastern Virginia. The distribution records obtained from this survey for each of the three species of cotton-root aphids are shown on the map in fig. 1. None of the species were found in Florida.

A. maidi-radicis was found from southern Georgia to southeastern Virginia, although its damage to cotton in Georgia was slight, especially in the southern part. It was more evenly distributed, both as to frequency of occurrence and population per plant, from Virginia to northern Georgia, decreasing toward the southern part of Georgia. The other two

species were not found south of South Carolina, and both were more numerous in the northern extremities of the cotton belt.

Rhopalosiphum sp. was found only occasionally in South Carolina but was frequently found in eastern North Carolina and southeastern Virginia.

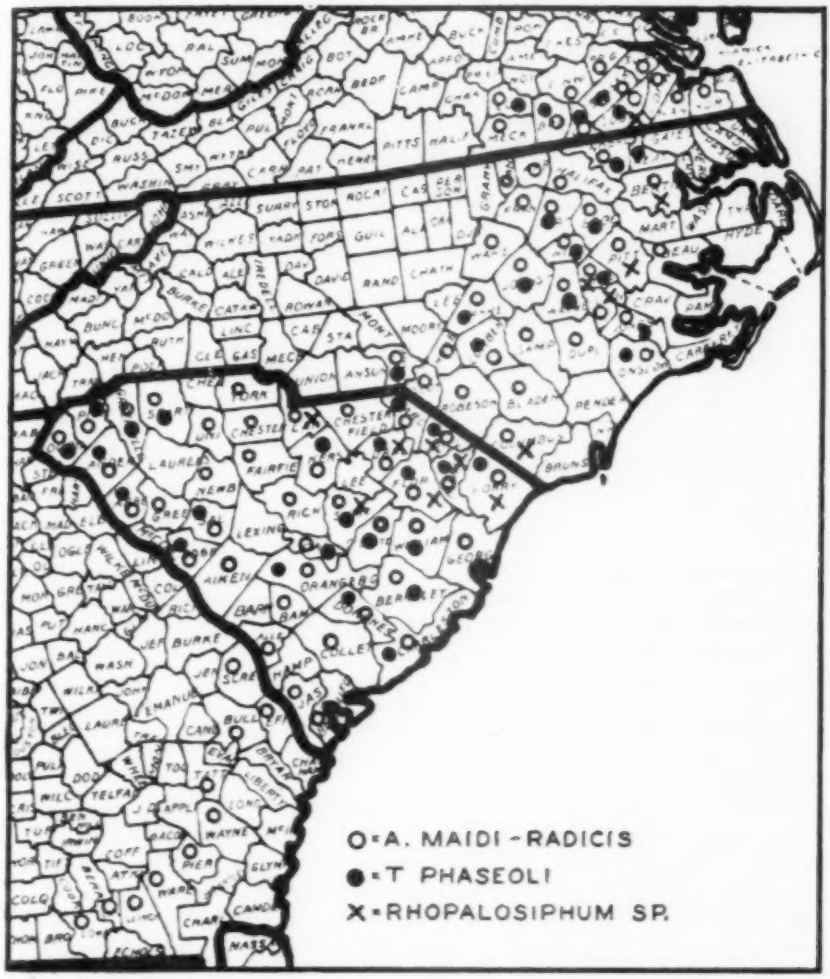

Fig. 1.—Distribution of cotton-root aphids in the south Atlantic states.

T. phaseoli occurred abundantly in some places in South Carolina but was more abundant in North Carolina and Virginia. Much more injury to cotton is caused by these root aphids in the two Carolinas and Virginia than is generally suspected. This is due to the fact that the

injury is not generally recognized and when the plants are being inspected the aphids are frequently overlooked. When heavily infested plants are pulled from the soil in the usual way, the aphids are stripped from the roots and no indication of their presence is left. The occurrence of ant hills around the base of the plants, however, is usually a positive indication that aphids are on the roots. If the infested plants are removed from the ground with the soil around the roots intact, the aphids can easily be seen adhering to the roots as the soil is gently shaken off. Many farmers were surprised that the aphids had caused the injury, as they had thought that ants had killed the plants.

During the winter of 1934–35 an effort was made to determine the manner and form in which these aphids overwintered in South Carolina and to learn their host-plant relationships. Each species was found to maintain the subterranean habitat continuously, without producing

Table 1.—Relation of temperature to life history of *Rhopalosiphum* sp.

Temperature °F	Av. No. Days in Developmental Period	Av. No. Days in Adult Life	Av. No. Young Produced
40.1–45.	25.3	14.5	16
45.1–50.	20.2	14.4	20
50.1–55.	19	16.1	30.8
55.1–60.	14.6	15.1	38.4
60.1–65.	10.8	13.9	45.4
65.1–70.	7.9	11.6	48.7
70.1–75.	6.4	9.6	40.6
75.1–80.	5.8	9.1	39.2
80.1–85.	4.7	7.4	36.3
85.1–90.	4.7	7.1	38.5

sexual forms. Asexual females and nymphs were found on different hosts throughout the winter. The adult females were usually wingless, but occasionally alate forms were found. During cold weather the females are inactive, their rate of reproduction greatly decreased, and their longevity increased. Likewise, the nymphs are inactive in cold weather, and the period between molts is increased. But when warm weather occurs during the winter months, both nymphs and adults resume their normal activities. The effect of temperature on the life history of *Rhopalosiphum* sp. is shown in table 1.

While the writer was making host-plant records of the above species other subterranean species[1] were found in the vicinity of Florence, S. C., namely, *Anoecia querci* (Fitch), *Anoecia corni* (Fab.), *Anuraphis* sp., *Aphis* sp. and *Forda* sp. *A. querci* was frequently found on the roots of grasses and evening primrose, goosegrass, *Eleusine indica*, being the most common host. Wingless adult females and nymphs were found during August, September, October and November. Host-plant records of all species collected are given in table 2.

Anoecia corni was collected from several hosts during September, October and November. Alate and wingless females and nymphs were the forms collected.

[1] Determinations by P. W. Mason, Division of Insect Identification, Bureau of Entomology and Plant Quarantine.

Aphis sp. was frequently collected from *Amaranthus* during September, October and November. Only asexual forms were collected.

Forda sp. was collected only once—from the roots of *Heterotheca subaxillaris* on September 22.

Rhopalosiphum sp. was reared through 70 consecutive generations in the insectary. The aphids were placed on sprouted cotton seed in a small vial and examined daily, the mouth of the vial being stopped with absorbent cotton. In this manner the humidity on the inside of the vial was kept constantly high. The vials were left in the insectary exposed to the air temperature the year round. A thermograph recorded the tempera-

Table 2.—Relation of subterranean aphids to host plants in the vicinity of Florence, S. C.

	1*	2	3	4	5	6	7
Cotton	x	x	x				
Corn	x						
Okra	x		x				
Field peas		x					
Butter beans	x		x				
Soybeans	x		x				
Cocklebur	x		x				
Smartweed	x			x			
Water grass					x	x	x
Crab grass						x	x
Nut grass							x
Crotalaria	x	x					
Croton	x						
Amaranthus spinosus	x			x	x	x	
Amaranthus hybridus	x			x	x		
Gnaphalium purpureum	x						
Gnaphalium spathulatum	x		x				
Gnaphalium sp.	x	x	x				
Erigeron canadense	x						
Erigeron ramosus	x						
Erigeron pusillus	x						
Diodia teres	x			x			
Richardia scabra	x						
Plantago aristata	x						
Chenopodium album	x					x	

	1	2	3	4	5	6	8
Chenopodium ambrosoides	x	x					
Heterotheca subaxillaris	x						x
Oenothera laciniata			x			x	
Oenothera sp. (*biennis*)	x						
Oenothera sp.						x	
Isopappus divaricatus	x						
Solidago altissima	x			x			
Solidago sp.	x						
Aster pilosus	x			x			
Aster sp.	x	x				x	
Ambrosia elatior	x					x	
Baccharis (*halimifolia*?)				x			
Hypericum sarothroides	x						
Eupatorium capillifolium	x						
Elcusine indica	x		x	x		x	
Brassica sp.		x					
Brassicaceae (species of)		x					
Sonchus sp.	x						
Carara didyma		x					
Linaria canadensis		x					
Helenium tenuifolium	x			x	x	x	
Arundinaria tecta						x	
Mustard		x					
Radishes		x					
Turnips		x					

* 1. *Anuraphis maidi-radicis*
2. *Trifidaphis phascoli*
3. *Rhopalosiphum* sp.
4. *Anuraphis* sp.
5. *Aphis* sp.
6. *Anoecia querci*
7. *Anoecia corni*
8. *Forda* sp.

ture continuously. A low temperature of 15° F was recorded, and during one period the minimum was below freezing in the insectary for 10 consecutive days, the mean for this 10-day period being 34.15°. Often the sprouts on which the aphids were placed were frozen solid. The aphids themselves would appear lifeless, but as the temperature rose the aphids would again become active. The mortality rate was higher during the low-temperature period, especially with the first and second-instar nymphs, but a sufficient number always survived to keep each generation going. In addition to retarding the normal life activities and causing a higher mortality, the lower temperatures caused an increase in the number of alate forms. These forms could always be produced by crowding several nymphs in a single vial, but only rarely did an alate form occur when aphids were reared singly at ordinary spring or summer temperatures. Table 1 shows the relation of temperature to the life history of this species.—10-7-36.

BOLL WEEVIL ACTIVITY DURING NORMAL HIBERNATION PERIOD AT TALLULAH, LA.

R. C. GAINES, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*[1]

During the six winter seasons of 1928–29 and 1930–31 to 1934–35, the cages for boll weevil hibernation at Tallulah, La., were examined daily except Sundays, weather conditions permitting, to determine the number of boll weevils active under cage conditions. The observations discussed in this paper extended each winter from December 21 to the end of February. Observations prior to December 21 were not included because of the possibility of recording weevils as active that had not actually entered hibernation. The primary purpose of the hibernation-cage

Table 1.—Relation between maximum temperatures and boll weevils observed active in hibernation cages, Tallulah, La., 1928–29 and 1930–31 to 1934–35.

Max. Temp.	Weighted Av. Max. Temp.	No. Weevils Active in Cages	Increase in Max. Temp.	Increase in No. Active Weevils in Cages	Increase in No. Active Weevils in Cages per 1 Degree Increase in Max. Temp.	Per Cent Weevils Found to be Active	
						Based on Av. Total No. in Cages	Based on Av. No. Weevils Survived
°F	°F	Daily Av.	°F				
36–45	42.2	5.5	8.9	4	.45	.016	.295
46–55	51.1	9.5	10	9.2	.92	.028	.510
56–65	61.1	18.7	9.3	4.3	.46	.054	1.004
66–75	70.4	23	7.4	39.7	5.36	.067	1.235
76–81	77.8	62.7				.182	3.366

tests is to determine boll weevil survival under given conditions, but these tests also afford an opportunity to study weevil activity in relation to certain weather conditions. Undoubtedly temperature, relative humidity and perhaps rainfall are the chief meteorological factors affecting boll weevil activity during the normal period of hibernation, but this paper deals only with maximum temperature in relation to activity. These examinations were made to determine the number of weevils that had left their hibernation shelter and were found alive on the sides and tops of the cages. They were not necessarily moving about, but it was always determined whether they were alive or dead. All weevils that were found to be alive were recorded as active. The examinations were made during the afternoon, and the maximum temperature on the day the record was made was considered to be the temperature affecting the activity.

Table 1 presents a summary of maximum temperatures and numbers of boll weevils observed to be active in the cages during the periods of

[1] The field work was performed by G. L. Smith, J. C. Clark and A. L. Scales.

the study. One weevil was found on a day when the maximum temperature was only 36° F, but all other weevils were found when maximum temperatures were 40° or higher. The greatest number of weevils were found to be active when maximum temperatures were above 65°. Of the total number of weevils recorded as active in the cages, 1 per cent were observed when maximum temperatures were from 36 to 45°, 7.6 per cent from 46 to 55°, 20.1 per cent from 56 to 65°, 36.9 per cent from 66 to 75°, and 34.4 per cent from 76 to 81°.

Since these observations were made almost daily it is probable that some weevils were counted more than once, or, in other words, that they remained active for more than one day. Weevils that became active and crawled up on the sides and tops of the cages either died or returned to hibernation shelter later. Assuming that no weevils were counted twice, 2.65 per cent of the total number of weevils confined in the cages were

Table 2.—Relation between maximum temperatures and number of boll weevils taken on screens during periods of normal hibernation, Tallulah, La., 1931–32 to 1934–35.

Max. Temp. Previous Day	Weighted Av. Max. Temp.	Daily Av. No. Weevils Taken on Screens	Increase in Max Temp.	Increase in No. Weevils Taken on Screens	Increase in No. Weevils Taken on Screens per 1 Degree Increase in Max. Temp.
°F	°F		°F		
62–65	63.2	1.5	8.3	3.8	.46
66–75	71.5	5.3	7.1	8.8	1.24
76–83	78.6	14.1			

found to be active during the normal periods of hibernation. Hinds & Yothers (*1*) stated that in 1906 and 1907 of the total number of weevils placed in hibernation cages 7.8 per cent were observed to be active at Dallas, Tex., during the normal period of hibernation; 10.5 per cent at Calvert, Tex.; and 27.7 per cent at Victoria, Tex. Perhaps a better indication of the relative number active can be determined from the daily observations and the average number confined each year. Based on the average total number, table 1, confined in the cages, only .182 per cent were observed to be active daily at Tallulah, La., with maximum temperatures of 76° F or higher. This percentage is low because some of the weevils died long before the end of February each year, thus reducing the total number of live weevils that might become active. Based upon the average number that survived the winters it will be noted that 3.366 per cent were observed to be active daily when temperatures were 76° F or higher. This figure is undoubtedly high because the number of live weevils over at least a part of the hibernation period was greater than the number that actually survived to emerge the following spring, so the true figure lies somewhere between these two. Lower percentages of weevils were found to be active at temperatures of less than 76°, the percentages decreasing in more or less direct proportion to temperature decreases.

During the four-year period 1931–32 to 1934–35, screens which were coated with a sticky tree-banding material were examined for informa-

tion on boll weevil movement in the field during the normal periods of hibernation. These screens were located in cotton fields where an infestation of weevils had existed during the previous growing season. The screens were 3 by 5 feet and had both sides exposed, making a total exposed area of 30 square feet per screen. Since different numbers of screens were used during some of the years, the number of weevils taken at each examination has been computed on the basis of 600 square feet of exposed screen area. The bottoms of the screens were placed 3 feet above the ground so that the exposed areas were between 3 and 6 feet above the ground—the altitude at which the greatest number of boll weevils are known to fly. During the first two of the four winters the screens were observed daily except Sundays, weather conditions permit-

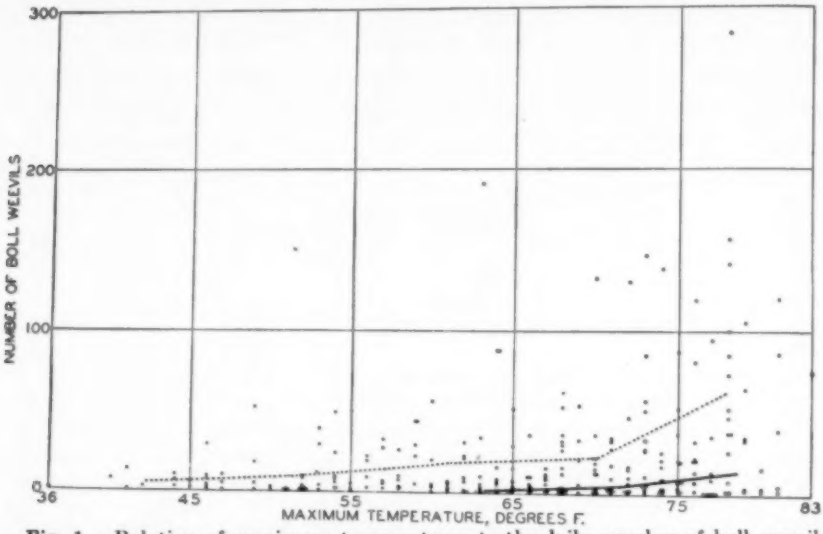

Fig. 1.—Relation of maximum temperatures to the daily number of boll weevils found to be active in hibernation cages and to the daily number of weevils taken on screens. The solid dots represent the daily number of weevils observed active in cages and the dotted line shows the average. The circles represent the daily number of weevils taken on the screens and the solid line shows the average.

ting, and during the last two years the screens were observed semiweekly. Only a few weevils were taken on the screens during these two years, so that the semiweekly observations are considered as daily. This paper presents the records made each year from December 21 to the end of February. These observations were usually made in the morning, so that the maximum temperature used as affecting boll weevil activity was the maximum temperature that occurred on the previous day in the case of the daily examinations, and the highest maximum that occurred between the observations in the case of the semiweekly examinations.

There was no weevil movement or flight at maximum temperatures of less than 62° F, and it will be noted in table 2 that the greatest movement occurred when temperatures were above 75°. A grand computed

total of 385 weevils were taken on these screens, of which 2.3 per cent were taken with maximum temperatures ranging from 62 to 65°, 32 per cent with temperatures from 66 to 75°, and the remaining 65.7 per cent with temperatures from 76 to 83°.

Previous investigators (*2*) have determined that the zero of effective temperature for boll weevils is 56° F, and it was assumed that active metabolism begins at this point. The observations presented herein indicate that maximum temperatures higher than 56° are necessary before actual flight takes place.

Figure 1 presents graphically the relation between maximum temperatures and daily boll weevil activity in the hibernation cages during the six-year period. The relation between maximum temperatures and daily number of boll weevils taken on screens during the four-year period is also presented.

Summary.—These observations show that a surprisingly large number of boll weevils become active during the normal period of hibernation. Under artificial cage conditions 1 per cent of the total boll weevil activity occurred when maximum temperatures ranged from 36 to 45° F. The screen records indicated that maximum temperatures of 62° F or higher are necessary before actual flight takes place.—10-5-36.

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PACIFIC SLOPE BRANCH

PAPER-READING SESSION, TWENTY-FIRST ANNUAL MEETING

Seattle, Wash., June 1936

OBSERVATIONS ON LIFE HISTORY OF LILY BULB THRIPS

LIOTHRIPS VANEECKEI PRIESNER

Ralph Schopp, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Biology of the lily bulb thrips, *Liothrips vaneeckei* Priesner, has been studied at Sumner, Wash., in the laboratory under partially controlled conditions and in the field. The two sets of data did not agree closely, the apparent durations of the stages being shorter in the laboratory. Hodson (*1*) in England published records still less in agreement with the field records than those at the Sumner laboratory.

Laboratory studies on duration of the stages.—Durations of the stages are greatly influenced by environmental factors, most of which are un-

known. In the experiments included here temperature was recorded but not closely controlled. The thrips were reared individually on lily scales in glass vials. Examinations were made daily except in the case of the prepupae, which were examined at intervals of eight hours. The laboratory experiments have provided the data in table 1.

Table 1.—Durations of the stages of *Liothrips vaneeckei* in the laboratory at Sumner, Wash.

Stage	No. Individuals	Mean Temperature °F	Days Duration		
			Average	Maximum	Minimum
Eggs	91	65.4	17.2	23	6
First-instar larvae	57	65.7	16	44	9
Second-instar larvae	48	66.7	19.9	83	8
Prepupae	103	68.3	2.8	4	2
Prepupae and pupae	57	67	13.1	15	10
Adults	57	68.5	70.3	222	8
Time of emergence to laying of first egg	14	67.8	25.5	109	10

Hodson (*1*) states that at temperatures fluctuating between 58 and 65° F the average durations of the several stages were as follows:

	Days
Egg	14
First-instar larva	9
Second-instar larva	11
Prepupa	2
Pupa	8
Emergence to egg laying	14

In comparison with the average total period of 44 days from egg to adult which Hodson reports, the same average of the Sumner, Wash., data was 66.2 days when the average temperature was between 65 and 70° F, and 48.2 days when the temperature range was about 70 to 75° F. With no information as to the technic used by Hodson it is not possible even to conjecture the reasons for the wide difference. It is evident that some important factor is involved, and that it is not temperature.

Developmental history studies in the field.—Natural seasonal development of the lily bulb thrips has been studied by weekly observations of gross populations in bulbs in the field. The numbers of each stage present, with the exception of the eggs, in each population sample were recorded and compared by representing them as percentages of the whole population. Early in the season, until the first peak of egg deposition subsided, the eggs also were counted, but later it was found impossible to determine the condition of all of them, since some failed to hatch. The overwintering individuals were chiefly second-instar larvae and adults in about equal numbers.[1] There also were present a few first-instar larvae, amounting to about 3 or 4 per cent of the total. Newly deposited eggs and the pupal stages were not observed in the winter

[1] Hodson (*1*) states that these stages are present in the winter months in England.

months in western Washington. The eggs appeared in the spring, a little earlier than the pupal stages.

In 1934, eggs were first noted on February 26 and pupal stages on March 26. In 1935 the first record of eggs was on April 17, and of the pupal stages on May 7. The resumption of developmental activities in the spring months is apparently greatly influenced by temperature.

The habit of passing the winter in two distinct stages that are well separated in the life cycle results in there being two slightly overlapping groups simultaneously going through their development in the same bulbs. In fig. 1 are graphic presentations of the data from the weekly examinations in 1934. These curves are smoothed by means of a 3-point moving average.

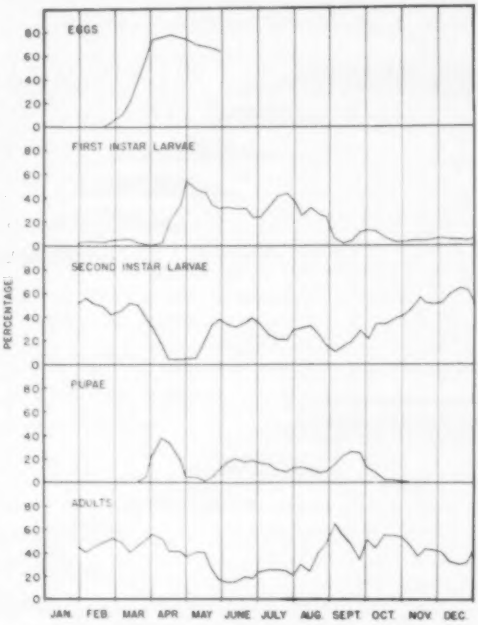

Fig. 1.—Percentages of the stages of *Liothrips vaneeckei* present at Sumner, Wash., during 1934. The percentages for the stages other than the egg stage represent the proportion of the total of those stages, exclusive of the eggs. The percentages for the eggs represent the proportion of the total of all stages.

The data of 1935 are similar to those of 1934 except that the proportion of larvae at the end of the season was lower. Destruction of the bulbs in the infested planting during the summer of 1935 reduced the amount of available material so greatly that clean bulbs had to be transplanted into the plot and infested during the summer. The later examinations during 1935 were of this material, which may not be comparable with the bulbs previously used. It appears possible, however, that one of the groups might be eliminated by shorter developmental seasons and that when such conditions prevail there would be only one group of individuals going through a single generation in a season.

In 1934 each of the two groups appears to have passed through about one and one-half generations, as is shown in fig. 2. That group developing from the overwintering second-instar larvae, after passing through the several stages, finished the seasonal cycle in the adult stage, while the overwintering adult group reached the second larval instar by the following winter.

It also appears from the seasonal-history data that the developmental period in the field from egg to adult was near 100 days. In the laboratory

at Sumner the development was somewhat more rapid. This difference indicates that the laboratory technic did not accurately represent field conditions.

Hodson (*1*) states, "the number of generations annually is at least four and may probably, under favorable circumstances, amount to as many as seven," although this would be qualified by another statement in his article, that "under outdoor conditions in this country the number of

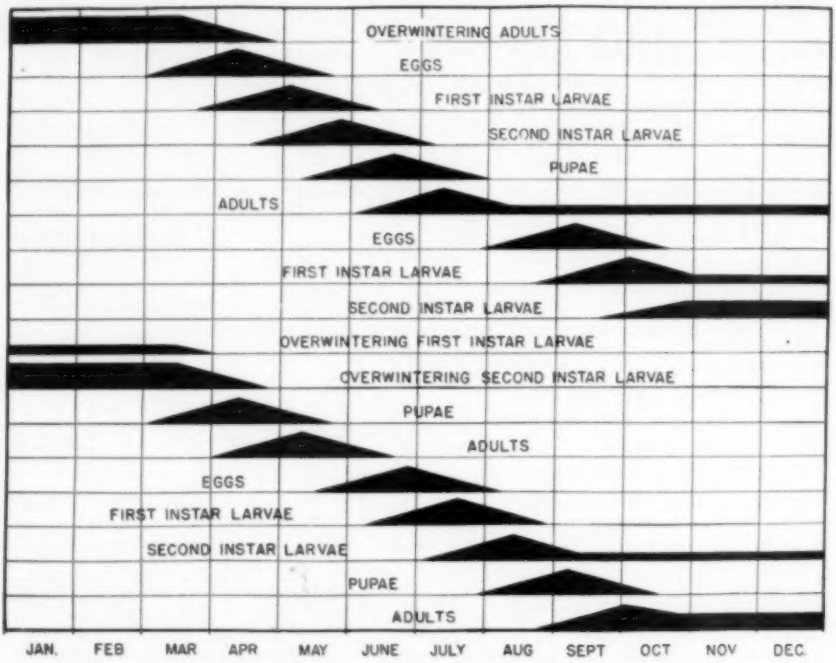

Fig. 2.—Diagrammatic interpretation of the seasonal history of *Liothrips vaneeckei* at Sumner, Wash., in 1934. Constructed from the data illustrated in fig. 1.

generations annually was not accurately determined, but appeared to be not less than four." These figures seem exceptionally high, in view of the natural population studies made at Sumner, Wash., where the climatic conditions do not differ greatly from those of England.

Summary.—In the natural development of the lily bulb thrips as determined by a study of the proportions of stages in natural population samples taken at regular intervals, there are two groups progressing from the two predominant overwintering stages. An alternation of the overwintering stage in each group is indicated, one developing from overwintering adults entering the following winter principally as second-instar larvae, and the other developing from overwintering second-instar larvae entering the following winter principally as adults. Life-history data obtained under laboratory conditions differed considerably from those ob-

tained in the field studies, which indicated that the laboratory conditions did not accurately represent the field conditions.—9-21-36.

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OBSERVATIONS ON BULB SCALE MITE AS A MAJOR PEST OF NARCISSUS

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Bulb scale mite, *Tarsonemus approximatus* Banks var. *narcissi* Ewing, has been considered for some time as a potentially important pest of narcissus. As the study of its habits has progressed the realization has grown that this mite is indeed one of the major pests of narcissus.

The mites feed principally on the epidermal surfaces of the scales in the bulbs. The scales are morphologically part of the leaves, adapted for food-storage purposes. The top, or neck area, of the bulb is the focal center of an infestation. During the growing season the mites concentrate in this part of the bulb, their activity extending upward to the point where the leaves separate, usually about the soil-surface line. Wherever sufficient space is available between scales the mites work their way in. In narcissus bulbs such openings are present because of a tendency of certain older scales to form partial folds and convolutions. Particularly is this true around the scale representing the flower stem of the preceding year, which does not develop into a circular scale, as do most of the leaf portions, but flattens out to become a division between the center portion and a slab or side shoot. The leaf scales adjacent to the old flower-stem scale are not completely circular, but form folds reaching just around the edges of the old flower-stem scale. Since during the growing season the mites are most prevalent in the neck area around the flower stem, they are in a favorable location to move downward into the scale portion of the stem as the top dies off, and are further benefited by the separations of the scales within the bulb during the dormant period.

During the dormant period of the narcissus bulb new shoots are developing. Early in the summer these shoots are very short, about one-fourth inch long in most varieties, but by fall they extend almost out of the "noses" of the bulbs. For a considerable part of this development the shoots are completely encased in thin sheaths, but as the tips approach the tops of the bulbs, these sheaths separate. As soon as this separation occurs, the mites are able to penetrate slightly into this new growth, and further penetration is possible with further development of the shoots. Also, the general shrinking due to the drying of the bulbs during this period enables the mites to extend their activities all through the top or neck of the bulb, making the chances very good that some of the mites will be ready to attack the new shoots as soon as the sheaths

separate. Under favorable conditions the mites multiply rapidly, and their feeding on the developing tissues causes distortion, stunting, and often killing of the leaves and flowers. Where the bulbs are used for greenhouse forcing, the conditions are usually favorable for the mites, and consequently there is economic loss due to the reduction both in the numbers and in the grade of flowers produced.

Where the populations of mites are large and their development is not retarded, longitudinal yellowish brown streaks are always present on the foliage and flower stems. The mites feed in the neck of the bulb, and as the leaves and stems grow away from the neck these feeding areas heal over, causing scarlike streaks. Frequently there are short transverse cracks in the scarred areas. Distortion and twisting of varying degree generally indicate the presence of mites, but the scar streaks are of more definite significance.

In the bulb-producing areas of the Pacific northwest the outdoor conditions are unfavorable for rapid multiplication of the mites, and in the field it is difficult to detect these symptoms of their presence. Not being aware of infestations, growers have sold bulbs in good faith to greenhouse operators, and these operators have suffered heavy financial losses from them. The seriousness of the problem is increased because the mites themselves are so small that in the absence of foliage symptoms the average grower can hardly be expected to detect their presence. Infestation within the bulbs is evidenced by moderately dark yellowish brown areas where the mites have fed, but the bulbs have to be cut open from neck to base and the scales and shoots separated for these areas to be observed. Places where the mites have worked for some time frequently have short transverse cracks in the tissues. In most cases the grower takes no control measures until he receives a complaint from a buyer or is in close contact with another grower who has had complaints.

In a survey of narcissus plantings in the Pacific northwest during the 1935 storage season, indications of infestations were noted in 14 out of 21 stocks examined for these mites. This proportion of infestation is not necessarily representative, since the samples examined were relatively small and infestations might exist in certain parts of the stocks that were not examined. These findings indicate a widespread occurrence of the mite, but in no case was the grower aware that his stock was infested.

Probably the only means of spread over long distances is through transportation of infested bulbs, commercially or otherwise. In the vicinity of Puget Sound, spread from bulb to bulb in the field is relatively slow. It is probably more rapid in warmer climates, for in an experiment under cool greenhouse conditions the mites spread from one central infested bulb to all other bulbs in a "flat" (shallow wooden tray or box used for forcing) within three weeks, the maximum distance of spread being 7 inches.

Although the studies have indicated that spread in the field is slow, certain stocks that had been under observation for several years showed a considerable increase in the number of infested bulbs, which could not be correlated with the information available on field spread. There were indications that this extensive spread had taken place while the bulbs

were in storage. Experiments to determine the extent and nature of spread under storage conditions were conducted by placing infested bulbs with uninfested ones and holding them under conditions approximating commercial storage. One infested bulb was used for every five clean or uninfested bulbs. The uninfested bulbs were "heat-treated" shortly before the tests were begun. After three months a sample of five bulbs was examined from each tray and the mites were counted. In the samples of single-nosed or round bulbs the spread did not extend to all bulbs, but in the bulbs that became infested the average number of mites present was 632. In double-nosed bulbs (bulbs with two flowering shoots) mites were found in every bulb examined, and the average mite population per bulb was 6058. The remaining bulbs in these tests were placed in flats and forced in the greenhouse. All were seriously damaged, producing only 15 per cent of a normal crop of flowers, not one of which was of marketable quality. It appears that spread of the mite from bulb to bulb while in storage or shipping containers is an important factor from the standpoint of economic damage.

Thermal treatments are the only dependable methods of control at present. Submerging the bulbs in warm water at 110° F for one hour effects complete mortality of all stages, with sufficient margin to allow for any variations which might occur in large-quantity treatments. Vapor-heat treatment will also effect complete mortality when used for two hours at 110–111° F. In both methods the period of treatment is exclusive of the time required for the bulbs to reach the treatment temperature. These treatments are best used for planting stock from which bulbs are to be selected for sale the following season. Bulb producers who have been following a general thermal treatment program for their stocks have experienced little trouble with this mite.—9-21-36.

PARASITIZING EUROPEAN EARWIG WITH *BIGONICHETA SETIPENNIS* FALL.

RECENT DEVELOPMENTS IN METHODS AND EQUIPMENT

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An initial stock of the tachinid parasite *Bigonicheta setipennis* Fall. of the European earwig, *Forficula auricularia* L., was sent from Europe to the Puyallup, Wash., field laboratory in 1931 and from this stock a series of experiments on propagation and colonization have been carried on. In the course of this work several methods and devices have been developed to reduce the time spent in routine operations and to speed up other special operations. Some of these methods and devices, especially those that might be applicable to work with other parasites, are described here.

Collection of host material.—Collection of earwigs for host material is begun about the time the majority reach the third instar. At this time

they are out of their nests in the ground in large numbers but have not yet started to disperse and find hiding places off the ground. At this time, too, most of the collecting can be done before the work of laboratory parasitization begins.

The trap, or hiding block[1] used in collecting earwigs consists of a pair of boards 4 inches wide and 1 foot long, each with eight longitudinal grooves three-eighths of an inch deep, three-sixteenths of an inch wide,

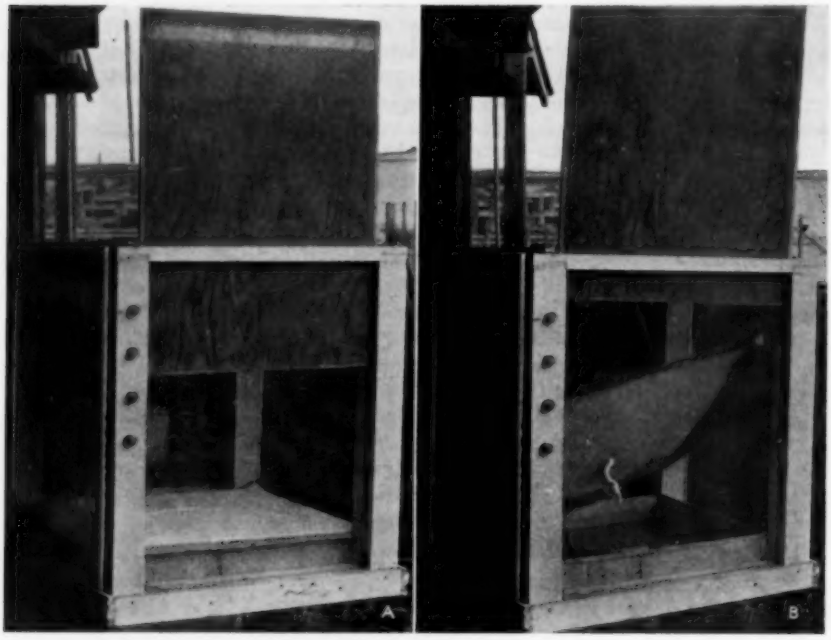

Fig. 1.—Mating cages, showing (A) sliding door, and (B) cellucotton pad on false bottom, pan of water, and wick for applying moisture to the pad.

and three-sixteenths of an inch apart, with the grooved sides fitted together. The traps are placed on end against trees, posts, sides of buildings or other places were earwigs are present. About a week is required for the earwigs to accumulate in numbers in the traps. A trap with both sides filled will hold about 5000 nymphs of the second and third instars or about 2400 adults. The earwigs may be quickly removed by opening the trap over an enamaled bucket and tapping one end on the rim. A ring of soft grease around the top of the pail prevents them from escaping. Earwigs thus collected are kept until needed in galvanized-iron cages or boxes and fed split raw carrots and a mixture of dried ground grass one part, fish meal three parts, and meat meal six parts. On this diet they thrive practically as well as in nature.

Emergence and mating.—Most of the parasite puparia are kept in

[1] Devised in 1930 in connection with earwig baiting experiments.

bulk lots in shallow pans and covered with about one-half inch of fine sand to keep out secondary parasites. When emergence begins, the pans of puparia are placed in a mating cage and left there for not more than a week, or until about 200 adults have emerged, whereupon the pans are moved to another cage. This saves time and injury to the flies by eliminating handling of them before mating. When the rate of emergence has increased to more than 200 in one day, the lots of puparaia are divided and placed in two or more cages. Puparia for seasonal-history studies are kept in No. 000 gelatin capsules in trays so that emergence can be easily watched.

The mating cages are 16 by 16 by 18 inches high, painted white and covered with 18-mesh galvanized screen, fig. 1. One side is fitted with a door of quarter-inch plyboard, which slides through a slot in the top frame, down through grooves in the side posts, and into a groove in the bottom frame, thus making a substantial, easily opened yet close fitting door that never sags or becomes loose. The bottom is closed with a sheet of galvanized iron, sliding also, through a slot in the left hand side of the lower frame, through grooves in the adjoining sides and into a groove in the opposite side. This slide may be removed for cleaning the cage or for placing it directly over a box of parasitized earwigs to allow the flies to come up into it as they emerge. When used as a mating cage continuous moisture is supplied by means of a cellucotton pad on a false bottom consisting of a flat, galvanized iron cover resting on a shallow pan on water in the bottom of the cage, fig. 1a. The cover extends to the screen on all sides and has a hole near the center through which passes a cellucotton wick sewed in cheesecloth for carrying the water up to the pad, fig. 1b. The pan and its cover are painted with waterproof paint.

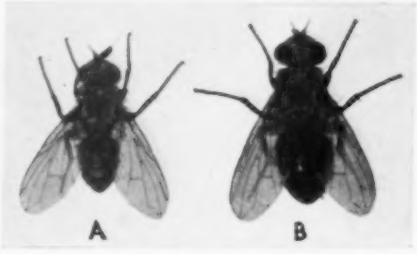

Fig. 2.—Adult *Bigonicheta setipennis* Fall. (A) male, (B) female. ×4.07.

Food is supplied by means of a pad of cellucotton on a 1 by 5 inch glass plate held by a clip in the upper, more illuminated corner of the cage. The pad is moistened with a solution of 2 parts of sugar and 1 part of water and allowed to dry before using. In fact, many pads are made up in advance of the parasitizing season. The sugar cements the pad to the glass. One pan of water and a pad of sugar will last at least two weeks, which is longer than the flies are usually left in the cages.

Mating is completed within three to five days after the last flies have emerged into the cage, and about a week later the females are transferred to oviposition cages. They can be easily distinguished from the males by placing the cage with the opening away from the light, opening the door and looking through at the flies as they crawl about on the screen. The females, fig. 2b, are usually larger and the abdomen is heart shaped, broad at the anterior end and rounded at the posterior end,

while the abdomen of the male is narrower and more pointed, fig. 2a. The males are left in the cage, to be used when a deficiency of this sex occurs later in the season.

Oviposition cages.—The oviposition cages are 10 by 10 by 5 inches with a sliding glass top and a bottom of curtain scrim of one-sixteenth-inch mesh, fig. 3. A 4-inch drawer pull on the front side facilitates handling the cage. Each cage has two food pads on glass plates, like those used in the mating cages. They are held in clips just beneath the top on opposite sides of the cage. Moisture is supplied by means of a pad of absorbent cotton on a 6 by 8 inch plate of glass beneath each cage. The cotton adheres to the glass and is remoistened once or twice a week by

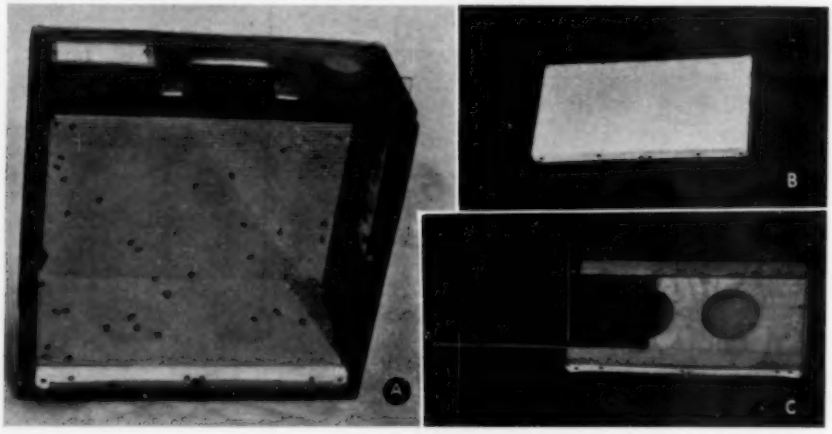

Fig. 3.—Oviposition cage and activators showing (A) cage with activator in place and flies ovipositing, (B) cloth-covered activator ready for use and (C) activator with slide partially removed to show compartments for live earwigs. Note food pads beneath the glass in the cage.

dipping it part way into a vessel of water. The pad should not be too wet. The cages rest on narrow shelves to allow passage of air. About 50 mated females are put into each cage and kept in a darkened room at about 70° F. At this temperature the preoviposition period is about 15 days.

Oviposition activators.—The activators are blocks of five-eighths-inch plyboard slightly shorter than the inside width of the oviposition cages and about one-half inch wider than the depth, fig. 3b. In each block are two $2\frac{1}{2}$-inch holes covered with screen. Two thicknesses of blotting paper, with holes corresponding to those in the block, are laid loosely over the screen. The top and sides of the block are covered with white, lintless, close-woven cloth sheeting and the bottom is fitted with a slide working in grooves. fig. 3c. A short time before they are needed the activators are "loaded" by pouring about 200 lightly anesthetized earwigs into each hole and closing the slide. As soon as the odor of the anesthetic has disappeared, the activators are ready for use, and they may be used for several days without being reloaded.

Anesthetizing outfit.—The anesthetizing outfit consists of a corked bottle of ether with an atomizer bulb to force air through it by means of a glass inlet tube extending through the cork to the bottom of the bottle, fig. 4. A short delivery tube passes through the cork and is connected by rubber tubing to another glass tube drawn to about 1 mm. opening and extending about 2 inches through a cork fitting the bottle of earwigs to be anesthetized.

Several 1, 2 or 4-ounce bottles are nearly filled with earwigs by knocking them from an earwig trap into a funnel in the bottle. The bottles are stoppered with corks having longitudinal slots for ventilation and are laid on their sides until one is needed, whereupon the cork is removed and quickly replaced by that of the anesthetizer. Ether vapor is then

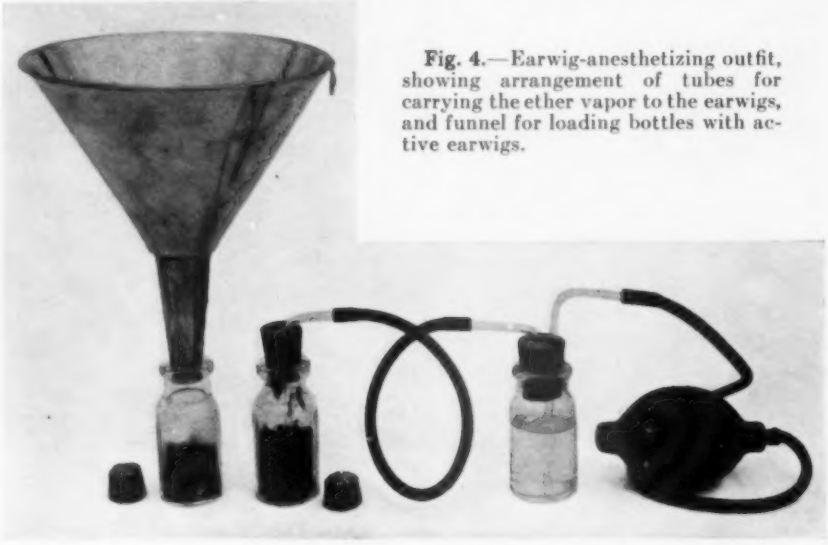

Fig. 4.—Earwig-anesthetizing outfit, showing arrangement of tubes for carrying the ether vapor to the earwigs, and funnel for loading bottles with active earwigs.

slowly forced into the bottle by depressing the atomizer bulb until the earwigs are rendered inactive. In undergoing anesthetization the earwigs pass through four stages. At first three is a period of increased activity, but gradually they relax and pass into the second, or quiescent stage. After a few seconds there begins a third stage in which the dorsal abdominal muscles contract so that the terminal segments are curved up over the back. This activity causes the mass of earwigs to "boil up" for a few seconds. They settle down again and go into the fourth stage, one of complete inactivity and muscular contraction. If the administration of ether is continued after the earwigs reach this stage, or if the bottle is kept closed, the earwigs will be injured and eventually killed.

Oviposition and parasitization.—When the flies are ready to oviposit, the cages are brought out into light and warmth, often out-of-doors but protected from the hot sun and placed on the rear side with the cloth bottom toward the light and with the glass cover in a position to slide

up to open. An oviposition activator is then inserted in each cage by sliding the glass cover upward just far enough to allow the activator to slide under it and be pushed in until the edge touches the cloth side of the cage, fig. 3a. Thus the flies cannot reach any part of the activator but the cloth-covered top. Several cages may be put into operation at the same time.

As soon as the flies detect the odor of their host, they begin to deposit eggs on the cloth directly above the earwigs. The eggs hatch in less that a minute, and since the maggots are also attracted to the earwig odor, the circular area over their prospective hosts soon becomes darkened with hundreds of maggots crawling and waving about on their anal bases.

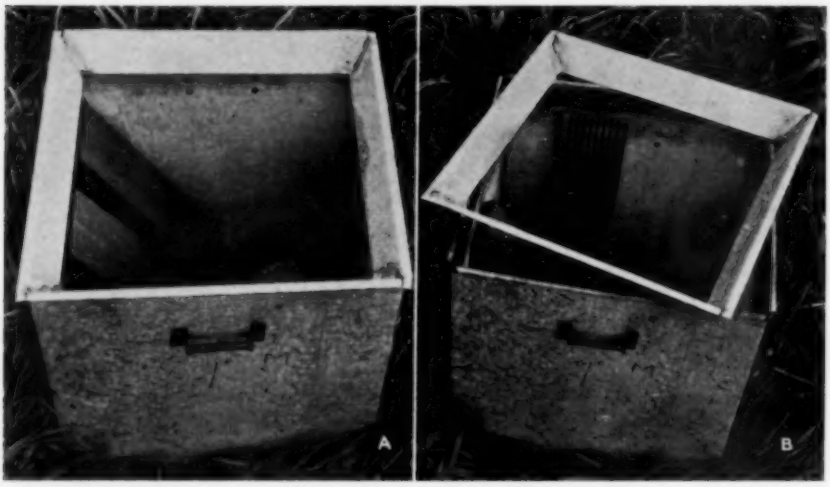

Fig. 5.—Earwig boxes, showing (A) the box in use with earwig traps in place and (B) the metal shield lifted to show the barrier of grease.

Few of them leave this area to wander about over the block. The block is left in the cage about an hour, during which 40 to 50 flies will deposit 1500 to 2000 eggs. It is then exchanged for a fresh block, and the maggots are used for parasitizing. This is accomplished either by using earwigs anesthetized to the fourth stage, picking each one up and bringing it in contact with a maggot on the block, or by the newer, "mass-production" method worked out in 1935. By this method the number of maggots over each hole in the activator is estimated, and a slightly greater number of earwigs, anesthetized to the second or quiescent stage, are poured over the maggots. They are then covered with petri dishes and agitated to aid in distribution of the maggots among the earwigs. After a few minutes the earwigs are shaken off, and practically no maggots will be found on the cloth. Subsequent examinations show that they average about 35 per cent parasitization and reveal no evidence of superparasitism, although a few earwigs may be found to be supporting two parasites. The percentage of parasitization and issuance of puparia under this method

compares very favorably with cases where earwigs are hand parasitized. About 80,000 earwigs were parasitized in 1935 in about one-tenth the time required to parasitize 75,000 by the old method the previous year. With an ample supply of flies and earwigs one person should be able to parasitize more than 25,000 earwigs in one day.

Recovery of puparia.—As the earwigs are parasitized, they are put into 15-inch-square galvanized iron boxes, fig. 5, with about an inch of fine sand in the bottom and with a 2-inch barrier of soft grease around

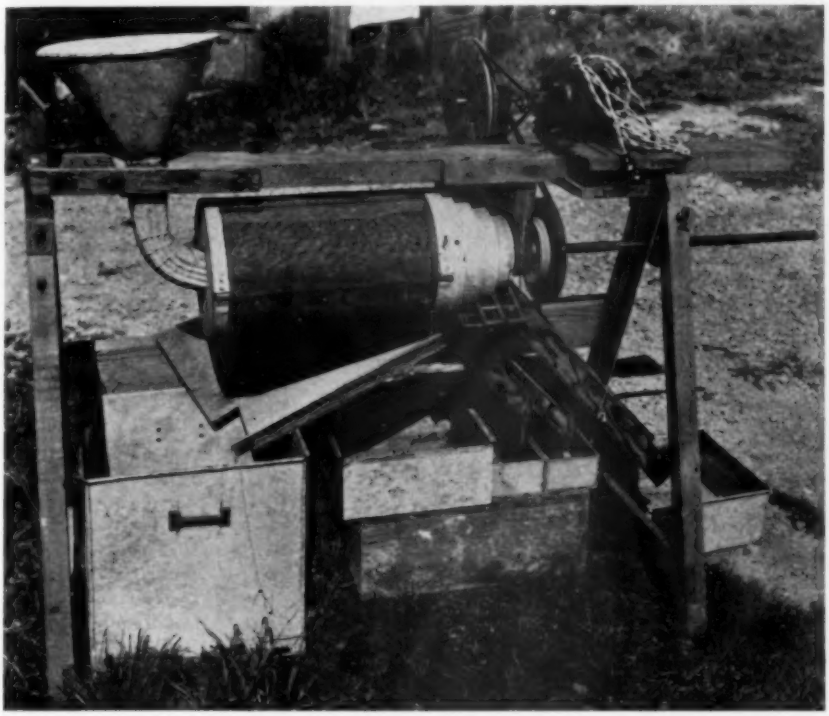

Fig. 6.—Rotary sifter, showing entrance of intake spout through disk to inside of smaller, inmost screen; also arrangement of jackshaft, screen shaft bearings and collars and spouts for delivering sifted material to the proper receptacles.

the top, which is protected by a metal shield. Regular earwig traps are supplied to accommodate the added parasitized earwigs. As many as 15,000 earwigs may be kept in one box. To facilitate separation of puparia, the food mentioned earlier is supplied in shallow pans so that the uneaten portions can be removed easily.

Since some flies start emerging in about 15 days after pupation it is necessary either to keep mating cages over the earwig boxes or to remove the puparia about every two weeks during warm weather. This is done by carefully lifting the traps filled with earwigs and quickly transferring

them to another box. The sand is then run through a rotary soil sifter designed for separating puparia from the soil.

Rotary sifter.—This sifter consists of four coaxial cylinders of 8, 12, 16 and 18-mesh screens, $5\frac{1}{2}$, 7, $8\frac{1}{2}$ and 10 inches in diameter, respectively, and 16 inches long, mounted on a shaft so that the screen of the largest mesh is inmost, fig. 6. The screens are supported at one end by metal bands of corresponding diameter soldered concentrically to a disk attached to a spider extending beyond the end of the shaft. The center of the disk is removed to allow insertion of the spout admitting the material to be sifted. Arrangement of the spout and funnel is shown in fig. 6. The other end of each screen terminates in a collar which is $1\frac{1}{2}$ inches longer than the one outside it, so that the material on that screen is carried out farther than that from the next larger cylinder, fig. 6. The collars are supported by four spokes on the shaft and spaced three-fourths of an inch apart. The shaft is supported by two bearings 15 inches apart, both at the delivery end of the screens. A series of spouts carries the sifted material from the screens to five different receptacles, fig. 6. Speed-reduction pulleys mounted on a jackshaft behind the motor reduce the speed of the screens to 25 rpm.

In use, the sand, which should be dry, is scooped from the earwig boxes and poured into the funnel of the sifter. As the screens turn, the finest sand passes through all the screens into the first box at the left. Some of the coarser sand passing the first three screens is caught by the last screen and delivered into the second box. The third screen carries off the smaller parts of dead earwigs, such as legs, forceps, abdominal segments and heads, and also some of the undersized parasite puparia. The second screen catches practically all the puparia, together with the ends of abdomens of dead earwigs, which are separated from the puparia later. The first screen carries off most of the dead earwigs and other trash.

By the use of the rotary sifter earwigs can be transferred and puparia sifted from five or six boxes per hour. The fine sand from the first box is returned to the earwig boxes and may be used repeatedly.

Field recovery of parasites.—To obviate the large amount of earwig collecting and rearing that is necessary to determine the parasite status of the 17 colonies situated at widely separated points in Washington and Idaho, a parasite trap, fig. 7, was devised to attach to the earwig traps already in use and thus catch parasites that might issue from the earwigs concentrated there. The combination traps can be leaned against buildings, fences or other places where earwigs abound, or by means of a simple wire clip may be hung on nails in trees. Cherry trees seem to be favored by both earwigs and parasites.

The parasite trap consists merely of a 30-gauge galvanized iron cup 2 inches deep, 2 inches wide and 4 inches long, made to slip over the end of the earwig trap so that the tension of the front side, which is sprung in slightly, holds it in place, fig. 7a. A bent strip of galvanized iron about one-half inch wide in the bottom of the cup supports the ends of the boards. It provides space for earwig excrement which would otherwise clog the grooves and prevent the parasite larvae from getting to the bottom of the cup to pupate. In later traps an inverted V notch was cut

in the lower ends of the boards to allow space for the accumulation of excrement, thus obviating the metal strip, fig. 7b.

In use, the parasite traps are numbered and distributed about the point of liberation or other places where records are wanted and their locations noted. Where record is desired only of the presence of parasites, the traps need be examined only once during the summer for cleaning, when necessary, and again in the fall for the presence of puparia. Some of the parasites will probably have emerged by that time, but the empty

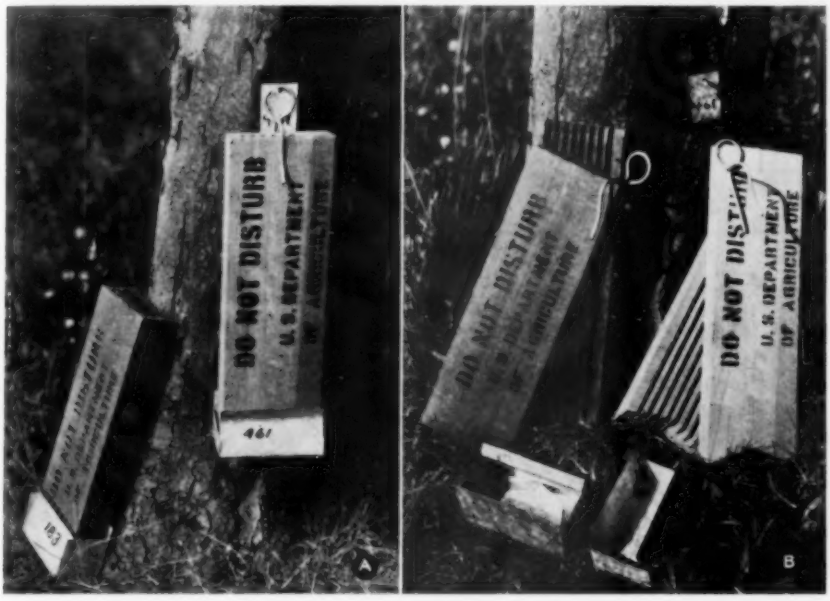

Fig. 7.—Earwig parasite traps; (A) in use, either hanging or leaning against a support; (B) showing clip for hanging, metal strip in cup, at left, for supporting end of boards when cut straight, and at right, inverted V notch in boards to provide space under the ends without use of metal strip in cup.

puparia will be found. The traps may be brought in and the accumulated debris dispersed in water and examined during the winter months. Where dates are desired and more frequent examinations are made, the cups are emptied each time. The puparia can usually be seen at a glance. The time required for examining traps is but a small fraction of that required for collecting and rearing the host with the attendant routine feeding and subsequent examinations. The trap results compared very favorably with those of rearing and were even superior in some cases in 1935, although the use of the traps was started late in the season and they were employed only on a small scale.

Accomplishments in 1935.—By use of the technic and methods just described, one person, during 1935, with part-time assistance during the parasitizing season, reared 8000 flies, parasitized 80,000 earwigs and

liberated 1800 gravid female flies and 500 puparia at 17 colonies in Washington and Idaho. Two hundred earwig and parasite traps were distributed and later examined at the colonies. Twenty-one thousand earwigs were collected and reared for recovery of parasites, 52 parasites were recovered from the traps and 73 parasites reared from earwigs brought in.

Summary.—Traps and methods are described for collecting earwigs as host material for the parasite *Bigonicheta setipennis* Fall., as well as mating cages and oviposition cages for the parasite. Methods of handling the flies during their emergence, mating, and preoviposition and oviposition periods are summarized. Equipment and methods are described for inducing oviposition, anesthetizing, parasitizing and caring for the earwigs and recovery of parasite puparia by means of a rotary sifter. A parasite trap for field recovery is delineated to obviate much collecting and rearing.—9-12-36.

CALIFORNIA CHRISTMAS BERRY THRIPS

RHYNCHOTHRIPS ILEX (MOULTON)

STANLEY F. BAILEY, *University of California, Davis*

Christmas berry or Toyon, *Photinia arbutifolia* Lindl., is widely used in California as an ornamental shrub. The California Christmas berry thrips is specific on its native host and is one of the few tubulifera in this state which are injurious. *Liothrips vaneeckei* Priesner, the lily thrips, and *L. varicornis* Hood, the hollyhock thrips, closely related species, are also plant feeders and to a minor extent injurious to lilies and hollyhocks. The life history of *L. vaneeckei* is known and that of *L. varicornis* is at present being worked out by the writer.

Moulton (*5*) described *R. ilex* in the genus *Trichothrips* in 1907 and Hood (*3*) in 1918 placed it in the genus *Liothrips*. In correspondence Moulton states that he now believes it to belong in *Rhynchothrips*, with which the writer (*1*) concurs.

F. J. Spruyt, when a graduate student in entomology at Berkeley (1924–25), made certain life history observations on the campus, covering a period of about six months. This information was never published and is incorporated here.

The glossy black adults are about one-sixteenth of an inch long and have silvery white wings folded lengthwise over the abdomen. The adults pass the winter singly or in clusters chiefly in the curled leaves which they have produced by the season's activities, fig. 1a, but also under old scales, in tightly-woven spiders' webs, etc., on the host. As many as 20 adults are often found clustered together. Hibernating adults of *Leptothrips mali* (Fitch) and *Hercothrips fasciatus* (Perg.) have been found in company with *R. ilex*. Adults kept at 40° F (constant temperature) for three months during the winter apparently suffered no harm and must survive much lower temperatures since the species has been collected up to 3500 feet in the Sierras (east of Placerville).

With the advent of new plant growth in the spring, the adults come out of hibernation, mate and begin feeding on the unfolding leaves. This early activity takes place from the last of February to the first of April, depending on the season, locality and altitude. About 10 to 15 days later the first eggs are laid on the old leaves or preferably among the heavily pubescent new leaves, particularly on the upper side. The eggs (about .4 mm. long) are deposited loosely on the leaf surface either singly or in irregular clusters. As many as 80 have been counted on the upper curled

Fig. 1.—Curled leaves of California Christmas berry caused by *Rhynchothrips ilex* (Moulton). (A) Old injury showing unsightly appearance; (B) fresh injury to new growth.

surface of an unfolding leaf a little more than one-half inch in length. The color of the eggs is a light brownish yellow with a slight appearance of a white wax on the irregularly reticulated surface. Individual females have been observed to deposit up to 11 eggs each. It is not known whether parthenogenesis occurs in this species. The ratio of females to males is about 2:1.

The egg stage has varied from a minimum of 13 days in the laboratory to seven weeks in the open in the vicinity of Fairfield (Solano county). The length of the egg stage under field conditions in the spring is usually from three to four weeks.

The larvae upon hatching feed together with the adults on the new growth, causing the leaves to become distorted, curled, fig. 1b, and even killed when the infestation is severe. A witch's-broom effect is often produced on the severely injured terminals. As the egg-laying continues

over a period of a month, so does the hatching. The over-wintering adults often live two and one-half months in the spring. The larvae are a pale yellow when first hatched and, as they develop, the tip of the abdomen becomes reddish black and two areas of the same color appear on the prothorax. The antennae, head and legs are brownish black and the remainder of the body is reddish orange. The larval stage consumes 18 days to four weeks. Moulting occurs once on the host when about half grown and again when entering the prepupal stage.

It is interesting to note that the P. R. Jones collection of thysanoptera, recently cataloged by the writer, contains slides of all stages of this thrips. The specimens were collected in 1910 and 1911 by P. R. Jones and W. M. Davidson at Alum Rock, San Jose, and Congress Springs, Calif.

When mature, the larvae drop to the ground beneath the host and often spend as many as 18 days seeking out a suitable niche or crevice in which to pupate. They prefer the loose, dry top soil to the moister soil below. Mature larvae and pupae have also been found in cracks of the bark at the base of the toyon bushes, under rocks, curled leaves, in stumps, etc. In the laboratory the prepupal stage lasts two days on the average and the pupal period consumes eight to 15 days. Under field conditions the pupal period lasts about two weeks. After transforming, the adults remain quietly in the place of pupation from one to three weeks.

The host blooms normally in June and July, depending on the locality, and it is at this time that pupation occurs. The adults are dead and, if the larval development has been rapid, practically no thrips are to be found on the shrub. Following the blooming period, a second flush of new growth often occurs which is injured very little, fig. 1a. The first newly emerged adults crawl to these new leaves. Adults have also been observed to feed on the green berries. Only a small amount of feeding is done and few eggs are laid. The second-brood larvae mature about the first of October, and it is doubtful that the pupae survive the winter rains. Many adults do not appear to feed after emerging but immediately seek out a suitable place in which to hibernate. There is one complete generation with a partial second each year.

At Davis, where the insect normally does not occur, and when confined in cages on the host, continuous reproduction occurred from April to October. There were, under these conditions, three overlapping generations. Pupation took place in the cotton wrapped around the twigs over which the Cellophane cages were placed. The lengths of the various stages are, of course, dependent upon the temperature and are more prolonged under the cooler conditions existing at Berkeley than at inland points, Vacaville, for example. However, there is also some individual variation in the length of the various stages.

The above mentioned difference in local climate leads to a discussion of the distribution of *R. ilex*. As was stated above, as far as is known, this thrips is found normally and reproduces on only the one host, *Photinia arbutifolia* Lindl., although there are records of its having been taken on *Rubus* sp., tree malva, and hollyhock (*2*). It has been taken by

the author commonly in the following California counties: Alameda, Contra Costa, Eldorado, Los Angeles, Marin, Mendocino, Napa, San Benito, Santa Clara, Santa Cruz, San Francisco, San Mateo, Solano, Sonoma, and less abundantly in Humboldt, Colusa, Lake, Placer, Sacramento, San Diego and Yolo. It is most abundant in the coastal areas and in the interior is found rarely in the floor of the valleys but more often in the foothills, particularly near lakes, streams and on the shady side of hills. The high summer temperature of the great valleys appears to to prevent reproduction as does the high rainfall along the north coast.

The distribution of the host, however, as given by Jepson (*4*), is as follows: "Rocky mountain slopes and deep soil of canyon bottoms, 10 to 3500 ft.; Sierra Nevada foothills from Butte county to Mariposa county; coast ranges from Humboldt and Shasta counties south to San Diego county; south to Lower California." Careful collecting will doubtless extend the distribution of the thrips to most of the area where the host is found naturally, with the above-mentioned limitations.

Although the adults have fully developed wings, they have never been observed to use them. The natural spread appears to be very slow and largely by means of the crawling of the adults. When disturbed, the adults run about rapidly and curl the tip of the abdomen up and forward after the manner of a scorpion. Artificial dissemination takes place largely on nursery stock moved during the dormant period when the adults are hibernating on the host (which is an evergreen).

Where infestations are severe enough to render the host unsightly when employed as an ornamental, the following control measures are suggested: Pick off and destroy all curled leaves in the fall, winter or early spring. As soon as the adults or larvae appear on the new growth in the spring, spray with a contact insecticide such as nicotine sulfate at the rate of one-half pint plus about one-half pound of spreader per 50 gallons of spray. A dust does not penetrate the curled leaves as well as a wet spray. Hosing off the plants with water and thoroughly wetting the ground beneath the infested shrubs during the summer will greatly reduce the numbers present.—9-8-36.

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A SECOND REVISION of the Missouri intrastate quarantine No. 1 pertaining to the Japanese Beetle became effective October 20, 1936, according to J. C. Breshears, commissioner of the Missouri Department of Agriculture. This revision extends the limits of the infested area to meet the present infestation in St. Louis. No materials capable of carrying this beetle are allowed to be moved outside of this area without a permit issued following adequate treatment.

OMNIVOROUS LEAF TIER,[1] *CNEPHASIA LONGANA* HAW.

A RELATIVELY NEW PEST OF STRAWBERRIES, IRIS AND OTHER CROPS IN OREGON[2]

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During the season of 1929, specimens of larvae which were tunneling into strawberries were sent to the Department of Entomology by J. J. Inskeep, Clackamas county agricultural agent. As this was the first case of injury to strawberries of this type reported in Oregon, an attempt was made to rear the larvae to the adult stage so that specific identification of the pest could be made. Of the material received, one adult moth was reared and then sent to the Division of Insect Identification, U. S. Bureau of Entomology and Plant Quarantine, for determination. The insect was later reported by Mr. August Busck to be a male *Cnephasia longana* Haworth,[3] a new form for North America, but one which had been described approximately 100 years before in Europe.

Experimental workers of the U. S. Department of Agriculture collected lepidopterous larvae from Dutch bulbous iris in Portland also in 1929, reared them to the adult stage and had them determined as *C. longana* Haw.

The appearance of a new pest on two cultivated crops in Oregon, which was potentially extremely serious in an economic sense, caused considerable apprehension among growers and experimental workers. The desirability of conducting a study of the life history and habits of this insect was emphasized by the fact that very little literature was available in European publications, and this was confined almost entirely to its taxonomic position within the microlepidoptera.

Description of the various stages. ADULT MALE.—The adult is a tortricid, measuring nine thirty-seconds of an inch in length and with a wing spread of three-quarters of an inch. In color the forewing, body, head, patagia and collar are of a grayish yellow; the rear wings appear slightly less yellow, due possibly to a lesser number of scales. The under side of the forewing appears to be darker than the upper side, while on the rear wing both sides are of the same shade. The anal margin of the hind wing, from apex to base, has a fringe of long gray hairs, which attain a length of almost half the width of the rear wing on that portion of the margin close to the base. The apexes of the wings are somewhat rounded, giving the appearance of the typical tortricid.

The antennae are grayish yellow, though somewhat darker than the

[1] The common name of this pest was approved as the strawberry fruit worm by Committee on Common Names of Insects in 1935, JOUR. ECON. ENT. 28(4):726. Because this name is misleading in an economic sense and does not indicate accurately the general habits of the insect upon its varied host plants, the authors are using the above title name suggested by Mr. L. P. Rockwood, entomologist, Bureau of Entomology and Plant Quarantine. It is hoped that by this action the approved common name may be reconsidered by the Committee on Common Names of Insects.

[2] Published as technical paper 248 with the approval of the Director of the Oregon Experiment Station. Contribution of the Department of Entomology.

[3] Lepidoptera, family Tortricidae.

wings. The palpi are covered with scales; broad at the tip; somewhat ascending; reaching slightly above the vertex of the head.

Front portion of the tibia and femur of the forelegs is washed with brown and the tarsi are dark brown. The femur and tibia of middle and hind legs are grayish white; tibial spurs are yellowish gray. Middle legs are clothed with scales except on the tibia where there is a brush of hairs.

The anal tuft is fan shaped and yellowish gray.

ADULT FEMALE.—The female moth is similar in size and shape to the male but differs in color. The forewing is grayish with brown markings. The brown upon the forewing varies from a few mottled spots to, in extreme cases, practically covering the entire wings.

PUPA.—The pupa is typically lepidopterous, nine thirty-seconds of an inch in length; abdomen somewhat lighter than the rest of the body. The first to sixth abdominal segments have a double row of short spines on the dorsal side. These spines grow smaller progressing posteriorly until they are mere indications on the sixth segment. The anterior of these two rows of spines start at a spiracle and run over the back, ending at the spiracle on the other side. On each side of the pupa, running parallel with the spines, there are three setae, and another slightly ventral and anal in direction from the spiracle may be found.

LARVA.—The larva is a typically naked tortricid about seven-sixteenths of an inch long. The color changes as the larva grows. After hatching, the body retains the salmon color of the egg and this persists through the overwintering period in the hibernaculum. Shortly after the resumption of activity in the spring, the insect's body varies from a light to dark gray and the head capsule and shield become very dark. When a length of one-quarter to three-eighths of an inch is reached, a longitudinal stripe appears slightly to each side of the dorsal surface, though these disappear or become very faint shortly before pupation, and the larva turns to a creamy brown. The head capsule and shield become and remain tan after one-fifth of an inch is reached, except immediately after each molt, when they are very light. There are five ocelli on each side of the head close to the base of the antennae and slightly lateral, that are arranged in a compact group. The mandibles are dark brown and small. One pair of true legs is found on each thoracic segment and a pair of prolegs on the third, fourth, fifth, sixth and tenth abdominal segments. Characteristic of the larvae of the genus *Cnephasia* is the absence of seta VI on the ninth abdominal segment.

EGG.—The egg, when first deposited, is light salmon but turns darker if the egg is fertile or lighter if infertile. It is about one-thirty second of an inch in diameter, has no definite shape, though it is generally round but flattened at the point of attachment. During incubation the egg becomes somewhat irregular or collapsed in appearance.

Life history.—The following is the life history of *C. longana* Haw., based upon the data obtained to early June 1936. It must be remembered that seasonal differences in temperature, rainfall, sunlight, humidity, etc., no doubt cause considerable variation in the appearance and duration of the stages of the insect.

LARVA.—In general it may be said that the larvae appear on straw-

berry blossoms in the Willamette valley shortly after the Marshall strawberries begin to bloom. Larvae have also been found at this time or shortly after on wild strawberry and wild blackberry blossoms. Shortly after, or at the time the Dutch iris pushes out from its protective green sheath, the small larvae appear on this host. The worms are first noticeable in the strawberry fields when their characteristic work of webbing the petals is in evidence. At this time they have reached a length of one-eighth to one-quarter of an inch. Though it seems probable that they have been feeding on blossoms earlier, they have not been found because of their small size. In color the larvae at this time are from a light gray to a dark gray while the head capsule and shield are black. Later, during subsequent molting and growing of the worms, a pair of longitudinal stripes appear with a lighter stripe between on the dorsal surface, and the head capsules and shields turn to a tan or brown when the larvae are about three-eighths of an inch long. Shortly before pupation and when the larvae are approximately one-half inch long, these longitudinal stripes are much less noticeable though the head capsules and shields remain brown or tan.

PUPA.—Pupation begins about one month after the larvae are first noted in the field and continues for slightly over another month before the last larvae pupate. Preceding pupation the larvae web a portion of the petals, leaves or other plant material around them and remain quiescent for an indefinite period before the change to the pupae takes place. The time required for the change from the prepupal stage to pupa has been observed to be slightly more than 10 minutes. The newly formed pupa is light yellow but in a short time the dorsal surface acquires a pinkish color; this in turn darkens and in a day or two becomes tan, brown or dark brown though the ventral surface and abdomen are generally somewhat lighter.

The duration of the pupal period varies somewhat but will average about two weeks under insectary conditions.

ADULTS.—The adult moths appear, depending upon the season, from late May to late June and generally remain active until the middle of July or later, though in 1934 the last adults died in early July. At the time of emergence the pupae wriggle vigorously and manage to force themselves out of the webbed flower parts with the use of spines located on the dorsal surface of the abdominal segments. After working free or nearly free from the flower parts, the pupal case splits down the dorsal surface as far as the first abdominal segment and down the ventral surface as far as the tips of the wing covers. The moth then wriggles free of the case and crawls away for a short distance and awaits the distention of its wings. This process is completed in 10 to 15 minutes, and the adult is then ready to begin its life function.

The female moths mate and start laying eggs in about two days to one week after emergence under insectary conditions. Mating has been observed only a few times and then during the morning so it appears probable that copulation occurs during the night or early in the day. Egg laying has never been observed in the field. In the insectary the moths are kept in glass tubes for observation, and in these containers the females

exhibit a tendency to deposit eggs upon the glass and cotton plugs rather than upon plant material. Usually they oviposit during the night, beginning in some cases before 9 p. m. and occasionally lasting until after 3 a. m., while other moths have been observed laying during the day. Under these conditions the moths lay eggs singly and in clusters, with the total number of eggs running from 100 to more than 200 eggs.

The life of the individual adult moth is short, lasting from a few days to nearly two weeks.

EGG.—The eggs have never been observed in the field, due no doubt to their small size. In cases where moths have been confined in small cages over strawberry plants, eggs have been found generally upon plant debris while some have been deposited on green strawberry leaves and on clods of dirt. Under these conditions eggs are generally deposited singly but in glass tubes many are found in clusters.

When deposited, the eggs are light salmon, turning somewhat darker if fertile and lighter if infertile. During the incubation period the eggs shrink or flatten, giving them a collapsed appearance. The time required for incubation varies considerably, taking 11 to 20 days and averaging 14.6 days in 1932, 15 days in 1933 and 16.9 days in 1934.

LARVAE (NEWLY HATCHED).—Data secured in 1933 and 1934 indicate that the newly hatched larva leaves the egg and remains active for a short time, during which a suitable place is found and a hibernaculum of silken web is built. At this period it appears probable that these minute larvae do not feed and apparently no feeding is done until the winter has been passed in the hibernacula and the spring weather causes a resumption of activity, and they leave the overwintering webs to start the normal feeding upon the host plants. Development at this period appears to be somewhat varying as larvae observed leaving the the hibernacula during March 15 to 28, 1934, were less than 1 mm. in length, and larvae found in the field on strawberries and iris on April 18, 1934, were one-eighth inch plus to three-eighths of an inch in length.

Host plants.—The known host plants of *C. longana* Haw. are distributed in 12 plant families, and constitute 29 common plants. In addition, it appears probable that several, if not many more, plants will be found supporting this insect. The host list follows without regard to importance or extent of infestation:

Betulaceae

Filbert, *Corylus* spp.

Compositae

False dandelion, *Hypochaeris radicata*
Bachelor button, *Centaurea cyanus*
Ox-eye daisy, *Chrysanthemum leucanthemum* L. var. *pinnatifidum*
Wild sunflower, *Wyethia angustifolia*
Woolly sunflower, *Eriophyllum lanatum*
Yarrow, *Achillea millefolium*
Dog fennel, *Anthemis cotula*
Pineapple weed, *Matricaria suaveolens*

Convallariaceae

Asparagus, *Asparagus officinale*, reported by J. F. Bock, horticultural inspector, Clackamas county.

Cruciferae

Mustard, *Brassica compestris*
Wild radish, *Raphanus raphanistrum*
Cultivated radish, *Raphanus sativum*
Shepherd's purse, *Capsella bursa-pastoris*

Graminaceae

Wheat, *Triticum sativum*

Iridaceae

Bulbous and root stock iris, *Iris* spp.

Leguminaceae
Clover (alsike, white and red), *Trifolium hybridum, T. repens, T. pratense.*
Vetch, *Vicia* spp.
Peas, *Pisum sativum*
Alfalfa, *Medicago sativa*
Lupine, *Lupinus* sp.

Linaceae
Flax, *Linum usitatissimum*

Moraceae
Hops, *Humulus lupulus*

Papaveraceae
California poppy, *Eschscholtzia californica*

Polygonaceae
Wild buckwheat, *Polygonum convulvulus*

Rosaceae
Strawberry, *Fragaria* spp.
Rose, *Rosa* spp.
Wild blackberry, *Rubus macropetalus*
Fivefinger, *Potentilla gracilis*

Injury.—Typical injury to several economic host plants is described following:

STRAWBERRY.—The injury is done to both blossoms and fruit. The larvae appear soon after the blossoms unfold, and after webbing the petals over the center of the flower for protection they feed upon the pollen. This feeding destroys both the pollen and the developing fruit, or at least removes any possibility of a normal berry. Upon the fruit the injury consists of tunnels which penetrate the berry, starting generally under the cap. The amount of tunneling varies greatly; in some cases the fruit is riddled, while in others only a small amount of feeding is done and the injury might aptly be called a "sting." The tunnels within the berry are usually filled with frass and excrement, even when the larvae are no longer present.

DUTCH IRIS.—Damage to the bulbous iris is confined to the flower parts. Generally the feeding is mostly upon the pollen, though in some cases additional feeding is done. Occasionally the worms enter the blossoms before it has unfurled and the injury later gives the iris a "shothole" appearance. So far as is known the bulb of the iris is not attacked.

FLAX.—The larvae of *C. longana* Haw. by their feeding upon flax are at least a potentially serious pest of this crop. By webbing and feeding on the tender growing tips of the flax, the worms cause a cessation of growth of these parts and the plant then sends out one, two or more lateral shoots below the injury. The result of this feeding consists of shortened fibers and a decided lowering of quality of the ultimate product. The flower is also attacked and in cases of severe infestation this may result in a lower yield of flax seed.

PEAS.—Feeding by the larvae on this host is mainly upon the flower parts and occasionally upon the developing pod. If the injury to peas occurs early in their development, a reduction in yield may be expected.

WHEAT.—The first record of *C. longana* Haw. feeding on wheat was received in the season of 1935. The wheat kernels, while in the soft dough stage, were attacked and mostly consumed, and this injury was accompanied by webbing and considerable frass. Mr. L. P. Rockwood, entomologist, Bureau of Entomology and Plant Quarantine, investigated a field of wheat attacked by these worms and estimated that about 5 per cent of the heads of wheat were damaged.

HOPS.—The injury to hops is that of a typical leaf roller, consisting of webbing leaves together and feeding within this protection. If the feed-

ing is done on the terminal buds, growth is probably retarded until lateral shoots develop. It is very doubtful, however, that the yield is affected, since the larvae have pupated and become adults before the hop clusters are formed.

FILBERT.—The damage of the larvae on filberts is comparable to that on hops–webbing the leaves and feeding on them. The possibility of serious damage also depends upon the portion of plant attacked and in general it appears that although the tender leaves are especially attractive, serious injury is not likely unless the larvae are numerous.

CLOVER, VETCH AND ALFALFA.—In some localities the worms have been found to be numerous upon the blossoms of alsike, white and red clover. The feeding should cause little damage to these crops except in the case of seed production, which may be reduced by the destruction of the blossoms.

The larvae have been observed to attack both wild and cultivated vetch in numbers and alfalfa to a lesser degree. Damage to these crops appears to be temporary and the host plants overcome the loss after the larvae leave the plants.

WILD FLOWERS.—Injury to the various wild flower hosts is quite similar. The flowers are webbed together and the pollen grains, as well as the other flower parts, may be eaten.

Although the wild flowers are not of economic importance, they provide a source of food and continuing infestation for cultivated crops.

Parasitic Insects.—Five species of insect parasites have been recorded as attacking *C. longana*–three species of Ichneumonidae and two species of Braconidae. The determined species are listed as follows: *Phytodietus burgessi* (Cress.), *Glypta* sp., *Dioctes eureka* (Ashm.), *Microbracon hyslopi* Vier., *Microbracon gelechiae* (Ashm.).

Of the insect parasites, the last-named species appears to be far more important in controlling the larvae of *C. longana*. In some cases, during studies late in the larval period of the pest, it has been extremely difficult to find a worm which had not been parasitized by *M. gelechiae*. The parasite has been observed attacking the larvae on the majority of the known host plants. Whether any of these parasites will reach a status of parasitism sufficient to hold the pest in check is a matter of conjecture. In some localities parasitism has been observed to reach approximately 20 per cent, and in others no parasites have been found.—9-21-36.

EFFECT OF COLD STORAGE ON EGGS AND YOUNG LARVAE OF CODLING MOTH

E. J. NEWCOMER, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Occurrence of unhatched eggs of the codling moth on harvested fruit, especially on Bartlett pears, has been a source of annoyance to fruit shippers and canners in the Pacific northwest. During the process of

ripening the fruit, the eggs hatch, and fruit that originally was apparently not infested may become quite wormy.

In 1928 and 1929 the writer investigated the possibility of destroying these eggs by treating the fruit with dilute oil emulsions, and it was found that this could be done. It was also found that a few days' exposure to

Table 1.—Effect of a continuous temperature of 30–31° F on eggs and larvae of codling moth.

No. Days Eggs in Storage	Total No. Eggs	Per Cent Eggs Dead	No. Days Larvae in Storage	Total No. Larvae	Per Cent Larvae Dead
9	220	35	14	49	63.3
12	63	30.2	21	53	88.7
21	124	79.8	28	29	100
23	605	96.5	36	26	100
26	996	96.6			
28	220	99.5			
30	229	99.1			
35	123	99.2			

the lowest temperatures that the fruit would stand without freezing (28–30° F) would not kill a very large percentage of the eggs. These findings have been published (*1*).

Later, it was discovered that it was rather difficult to make practical use of the oil-emulsion method, because such treatment was very likely to interfere with the ripening of the pears. Further experiments with cold storage were therefore made. Observations were also made on young larvae still working under the skin of the fruit. If these could be killed, the fruit could still be used for canning, as the surface injury they caused would be removed when the fruit was peeled.

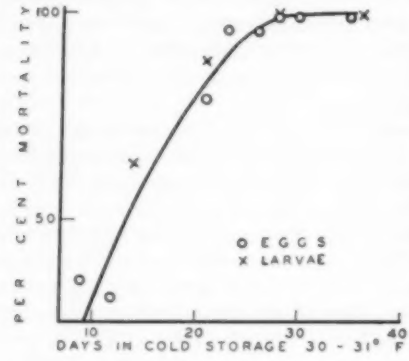

Fig. 1.—Mortality of eggs and young larvae of the codling moth in cold storage.

Apples were exposed to adult codling moths in cages in order to obtain eggs. Other apples containing young larvae were gathered in neglected orchards. Apples were used in preference to pears, as they were more easily handled. This fruit was placed in cold storage having an average temperature between 30 and 31° F,[1] and samples were withdrawn at intervals. These samples were placed in a warm room and the eggs and larvae were examined after a suitable time had elapsed. This temperature range was used because it is approximately what is employed in commercial practice for the storage of apples and pears. Lower temperatures would not be safe.

[1] The writer is indebted to A. L. Ryall, U. S. Department of Agriculture, Yakima, Wash., for cold-storage facilities.

The effect of a continuous temperature of 30 to 31° F on the eggs and larvae of the codling moth is shown in table 1.

These data are shown graphically in fig. 1, the curve being fitted by inspection. The effect of this temperature range on the eggs and young larvae is apparently very similar, and therefore no attempt has been made to indicate separate curves.

In addition to the young larvae which were still working just under the skin, incidental observations were made on older larvae which had reached the center of the fruit, and the percentage of these killed was as follows: 14 days, 10.4 per cent; 21 days, 18.2 per cent; 28 days, 55.8 per cent. Mature larvae, in cocoons, are of course not killed at these temperatures, as they survive long periods of cold during the winter. The young larvae, however, are evidently much more susceptible.

Conclusion.—It is concluded from these observations that storage of fruit for three and one-half to four weeks at temperatures of 30 to 31° F is necessary to effect a practically complete mortality of the eggs and young larvae of the codling moth which may be on or in the fruit. This temperature range is approximately that used in commercial practice for the storage of apples and pears.—9-21-36.

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EXPERIMENTS WITH OIL SPRAYS TO CONTROL RHODODENDRON WHITEFLY

Randall Latta, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Well-established infestations of the rhododendron whitefly, *Dialeurodes chittendeni* Laing, were discovered in 1933 on private estates in the vicinity of Seattle and Tacoma, Wash. Control measures have been investigated at the Sumner, Wash., field laboratory of the Bureau of Entomology and Plant Quarantine since 1934. Since more or less of an emergency existed because of the recent discovery of this insect, the most practical method that had potential promise of being effective was selected for trial, which in this case was judged to be a lubricating-oil spray. Among the average nurserymen and estate gardeners, spraying is the general method used for insect control, whereas dusting equipment is uncommon, and fumigation equipment is very limited in availability. From the practical viewpoint, then, some sort of spray would be the most feasible.

There is but one generation of this whitefly per year. The first-stage larvae are present through July and August, the second and third-stage larvae persist throughout the winter months, and the pupae become abundant in April and May until the adults appear in mid-May and June. Oil sprays were applied at different dates from December 5, 1934,

to October 10, 1935, to test their efficiency during the peak periods of all larval stages and the pupae.

Three types of oil and one commercial oil emulsion were tested. A so-called dormant oil with a viscosity of 100–110 seconds Saybolt and an unsulfonated residue of 74–76 per cent, and a heavy oil with a viscosity of 90–100 seconds and an unsulfonated residue of 94 per cent, were applied during the fall, winter and spring. In July and August a summer-grade oil, with a viscosity of 70–75 seconds and an unsulfonated residue of not less than 90 per cent, was tested. The commercial oil emulsion was applied under the writer's supervision by three different estate gardeners early in the spring.

In most of these applications an emulsion made by the casein-ammonia method[1] was used, but a few tests were made with tank-mixed emulsions using a commercially prepared spreader. No differences in effectiveness could be noted between these two methods of emulsifying the oil.

Applications of a 1 per cent spray (calculated on actual oil content) were quite definitely not complete in their effect, although the control obtained was reasonably good, especially in the use of the commercial oil emulsion. A 2 per cent spray produced complete mortality in several trials, but in others there were a number of survivors. Sprays prepared from a heavy oil at strengths of 3 and 4 per cent respectively, caused complete mortality in one test each. Four per cent dilutions of a summer oil gave complete control, but in one of two tests in which 3 per cent was used there was a single survivor. These results are tabulated in table 1.

Recommendations for control would depend on conditions existing at the infestation to be controlled. For best results 4 per cent strength of oil would seem to be necessary, but in a locality where the pest is generally prevalent, a 2 per cent oil spray should be sufficient for adequate control to insure satisfactory plant growth and flowering. Observations made in places where a control of better than 90 per cent was obtained indicated that the subsequent population increase was not plentiful enough to be injurious until the second year following the spray application.

The time of application would be optional, except that if control is effected before January there would be practically no formation of sooty mold fungus, which develops rapidly in the spring when larval activity is increased. Also, since the feeding of larvae does not cause discoloration of the leaves until the spring months, control measures applied in the fall would inhibit this type of damage.

The effectiveness of the oil sprays is dependent upon their contact with the insects, and the early fall months before frost or cold weather afford the best time to spray while the leaves are still erect. After cold weather comes the leaves of rhododendron droop almost to the stem and make proper coverage with insecticides difficult. In estate plantings the mechanical difficulties of spraying are intensified at all seasons by mixed growth, and the large size and spread of older plants. Since infestation is principally on the terminal leaves, efforts for spray coverage should be directed to those areas.

[1] The proportions used were as follows: Oil 1 gallon, water .33 gallon, casein (finely powdered) .03 pound ammonia (28 per cent) .01 quart. Adapted from Newcomer & Carter (*1*).

It was observed that nicotine sulfate was quite toxic to the adults. Wilson (*2*) in England recommends the application of nicotine dusts during the period of adult flight. In case of new infestations, control measures can be applied at once, no matter what the stage of development,

Table 1.—Mortality of *D. chittendeni* caused by oil sprays applied during 1934 and 1935.

Per Cent Dilution	Date Applied	Date Examined	No. Larvae Examined	No. Larvae Dead	Per Cent Mortality
		Dormant Oil			
1	Dec. 5, 1934	April 26, 1935	353	316	89.5
	Jan. 31, 1935	April 26	46	46	100.
	Jan. 31	April 26	419	356	84.9
	April 18	May 24	370	344	92.9
2	Dec. 5, 1934	April 26	536	496	92.5
	Feb. 26, 1935	April 26	420	420	100.
	April 4	May 17	140	140	100.
	April 4	May 17	574	574	100.
	May 2	May 24	258	234	90.6
		Heavy Oil			
1	Dec. 5, 1934	April 26	260	249	95.7
	Jan. 31, 1935	April 26	72	69	95.8
	Jan. 31	April 26	349	337	96.5
	April 9	May 17	607	487	80.2
	April 9	May 17	372	372	100.
	April 18	May 24	463	439	94.8
	April 25	May 24	469	467	99.5
2	Dec. 5, 1934	April 26	130	130	100.
	April 9, 1935	May 17	451	451	100.
	May 2	May 24	555	518	93.3
3	Oct. 10	Nov. 30	1941	1941	100.
4	Oct. 10	Nov. 30	1959	1959	100.
		Summer Oil			
3	Aug. 15	Sept. 13	30*	30	100.
	Aug. 31	Oct. 10	195	194	99.4
4	July 26	Sept. 13	13*	13	100.
	Aug. 15	Sept. 13	213*	213	100.
	Aug. 31	Oct. 10	170	170	100.
		Commercial Oil Emulsion			
1	Feb. 11	April 26	183	180	98.3
	Feb. 26	April 26	1498	1392	92.9
2	April 20	May 31	525	523	99.6

* Indications were that the larvae had dried and dropped off the leaf following the spray application, since the number of eggshells present would indicate a fairly heavy population.

by using oil sprays for the larval or pupal stages and nicotine sulfate in either a spray or a dust for the adults.

Incidental observations were made on the rhododendron lacebug, *Stephanitis rhododendri* Horv., in anticipation that control measures for one insect might have some value against the other. Negative results

were obtained, however, for lacebugs hatched from eggs on leaves drenched with oil sprays, and nicotine sulfate spray applied for lacebug control caused only partial mortality of whitefly larvae.

Summary.—Following the discovery of well-established infestations of the rhododendron whitefly, *Dialeurodes chittendeni* Laing, in the Puget Sound area, studies were inaugurated on controlling this pest.

Sprays containing 2 per cent oil produced high mortality of all the larval stages and the pupae, and are considered sufficient for commercial control. In infestations where complete control is to be attempted the strength of oil should be increased to not less than 4 per cent. No unfavorable plant reaction resulted from these applications.—9-21-36.

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EFFECT OF REDUCED TEMPERATURE AND PRESSURE ON HONEYBEE RESPIRATION[1]

Chas. E. Woodworth, *Walla Walla, Wash.*

Some time ago the writer (*4*) presented an article concerned with some effects on honeybee respiration of various reductions in atmospheric pressure. At this time it is desired to continue the discussion of the problem, bringing up the question of the effect of temperature and the combination of reduced temperature and reduced pressure. It is also desired to offer an explanation of some of the apparently contradictory results that have been obtained in other reduced-pressure experiments.

The honeybee, contrary to the condition found in most insects, has developed along with its social life an almost homothermal body temperature. While the bee is not equipped with more than an ordinary insect circulatory system, it has developed mechanical muscular means by which, under the normal conditions of hive life, it can raise or lower the colony temperature to the so-called "zone of comfort." This is accomplished, as is well kown, by means of fanning and has been sufficiently discussed by Phillips (*2*, p. 59) and Wilson & Milum (*3*), so need not be considered at this time. The experiments to be presented here along this line are actual measurements of the standard metabolism of bees, obtained at several temperatures.

Standard metabolism is defined as the metabolism under a standard set of conditions as near the maintenance or basal level as can be reached. It differs from the basal rate, however, in that several of the conditions required for human physiology cannot and need not be met. For ex-

[1] Data for this paper were obtained while the writer was assistant in economic entomology at the University of Wisconsin. Sincere appreciation is extended to Professor H. F. Wilson, who directed the study, and to John H. Lilly, who assisted in the experiments.

ample, the requirement that the patient go without food for 12 hours and remain quiet in a reclining position for an hour before readings are taken is not at all applicable in these experiments. The standard conditions used in these experiments were: First, the bees were placed in a wire cage that did not allow crowding, from a hive in greenhouse winter condition. Second, the pressure was quickly adjusted to the desired point and about 100 cc. per minute of carbon dioxide free air was allowed to flow through the chamber. Third, food (honey in a one-half dram vial) was available at all times, but none apparently was taken. Fourth, at least six hours of quiet was allowed before critical readings were started. Fifth, the lowest half-hour reading was taken as "standard metabolism," as this undoubtedly approached the basal or maintenance respiration.

Table 1.—Standard metabolism of bees at 700 mm. of Hg for various temperatures.

Temperature °C	Mg. CO_2 per Bee per Hour
10	.0528
15	.1468
20	.0704
25	.0704
30	.2024

Table 1 presents the standard metabolism at a pressure of 700 mm. of mercury at various temperatures from 10 to 30° C. The method of obtaining the results is the same as in the aforementioned paper.

From these figures it will be seen that at 700 mm. pressure there is a definite "zone of comfort" that extends through the normal range of temperature, namely 20 to 25° C. Both above and below this point the respiration is abnormally high. This is due to what might be called "irritation respiration" and is the attempt of the bees to regain the "zone of comfort." At 10° C this effect is reduced, probably to a minimum, as the bees were numbed into inactivity. The curve presented in fig. 1 is not the normal temperature curve in which there is a reduction of respiration proportional to the reduction in temperature according to the normal biological Q10, Krogh, or Van't Hoff-Arrhenius formulae. It might well be called the "bee irritation curve" and be classed as another exception to existing laws since insects, with their great diversity and specialization, successfully break almost all generalizations that have been drawn concerning animal life.

Table 2.—Standard metabolism of bees at 10° C for various pressures.

Pressure in Mm. Hg	Mg. CO_2 per Bee per Hour
700	.0528
500	.0528
300	.0116
100	.0158

It is interesting to note that the muscular activity at 15° C is about twice that at the "zone of comfort," and at 30° the activity has reached almost three times that of 25°. This latter was sufficient to raise the temperature in the reaction chamber to 31° in spite of the fact that 30° air was being circulated. This uncontrollable raise in temperature no doubt increased the activity, and the metabolism figures for 30° C should be a little lower than those recorded, but since this increase is due to the insect activity it was considered as part of the 30° reaction. At 10° C, numbing had set in, and muscular activity was greatly reduced. Table 2 presents the effect of various pressures while the bees are numbed.

These figures show that there is little difference in respiration between 700 and 500 mm. pressure. One drop difference in titration accounts for .0044 mg. per bee per hour in both of these readings, so the readings might be .055 and .05 and the difference not be recognizable. But, even at that there is slight difference in respiration between 700 and 500 mm. pressure. At the 300 mm. point the true reading is between .0087 and .0144, while at the 100 mm. point it is between .015 and .0166. The variation in the degree of accuracy of results as here noted is due to the fact that 10 bees were used for all experiments where the pressure was at all normal, but 15 and 50 bees were used at 300 and 100 mm. pressure, respectively, as both temperature and pressure were factors in reducing the expected results. Ten bees were used throughout the experiments reported in table 1.

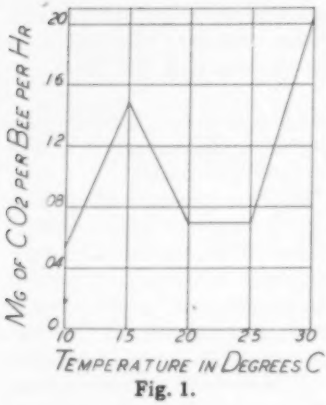

Fig. 1.

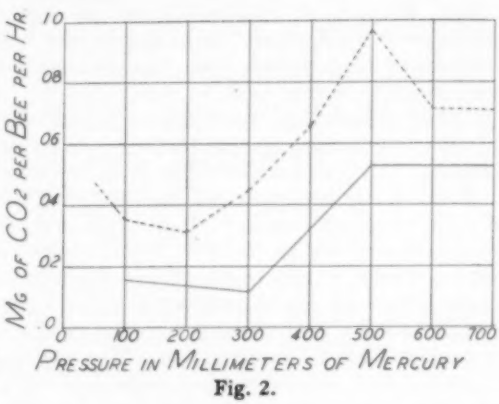

Fig. 2.

From the figures we see there is a very close correlation between the curves in fig. 2. The dotted line in this figure is a reproduction of the curve presented in the forementioned paper, and is included for comparison purposes only. The figures for it are not reproduced. It will be noted that the principle difference between the curves is in the fact that the 10° curve runs on a lower level than does that of 25°. Unfortunately, more points on this curve were not taken and the opportunity does not now present itself to get additional figures. However, the figures at hand do show a striking similarity.

There is also an interesting similarity between the curve of fig. 1 and curves of fig. 2. In fig. 1 between 20 and 25° C there is found the "zone of comfort," at 15° there is the "zone of irritation," and below that is a reduced respiration due to lowered temperature. In the dotted curve of fig. 2 there is a comparable "zone of comfort" between 700 and 600 mm.; at 500 mm. there is a "zone of irritation," and below that a reduced respiration due to lowered pressure. At 100 mm. and below, of course, there is an increased metabolism, due perhaps to excessive evaporation with consequent protoplasmic activity that does not have its counterpart in the temperature curve.

It is now desired to attempt to find why some results in reduced-pressure experiments are apparently so completely at variance. In the same issue of the JOURNAL that the article previously mentioned appeared (*4*), Dr. R. T. Cotton presented a paper on "The Relation of Respiratory Metabolism of Insects to their Susceptibility to Fumigants" (*1*). In that paper he brought out that factors which increased metabolism also increased susceptibility to fumigants. He pointed out that reduced oxygen content produced by reducing the atmospheric pressure increased respiratory metabolism. This finding appears to be diametrically opposed to that which has been presented in my paper since my thesis is that reduction in pressure in general reduces respiratory metabolism. I am supported in my findings by several authors, as reported in my previous paper (*4*), and Dr. Cotton also has several supporting authors.

There must be some reason for these contradictory results as both are correct beyond a shadow of a doubt. Upon examination of the original

Table 3.—Selected readings from an experiment to obtain standard metabolism. Pressure 300 mm. of Hg, temperature 25° C, 10 bees put in cage at 8 p.m.

TIME OF READINGS	CC. NaOH USED	NORMALITY	MG. CO_2 PER BEE PER HOUR
10:25 P.M.	4.9	n/10	2.156
11 P.M.	1.15	n/10	.704
11:35 P.M.	3.3	n/50	.2904
12:10 A.M.	1.1	n/50	.1056
12:45 A.M.	.5	n/50	.044*

* Standard metabolism.

data of the experiments upon which my papers are based we find results such as are given in table 3.

In table 3 it is noted that the first reading, in spite of the fact that it was taken two hours 25 minutes after the bees were put in, was 2.156 mg. CO^2 per bee per hour. This is almost 60 times that of the low reading .044. In the series of experiments records as high as 7.436 mg. per bee per hour have been taken 45 minutes after the bees were put in the cage. It seems that with the reduction in pressure there is an upsetting of the normal nervous balance and what might be called an "irritation" or perhaps a "compensatory" activity sets in. After a while this effect wears off and the true reduced-pressure normal is established. This may well be compared to the condition as found in human beings. If a man goes into the mountains to a pressure of about 500 mm. there is a marked increase in respiration and only a little activity requires added breathing, sometimes to the point of exhaustion. After a period of acclimatization a person establishes himself on a new level and, while he may breathe a little more deeply, there ie none of the violent breathing of the newcomer, even after considerable exertion. We have, then an explanation for the contradictory results that have been recorded. There are two effects, opposite in nature, that result from reduction in pressure. The first, a sudden increase in metabolism, has been utilized by Dr. Cotton in his vacuum fumigation, and the second, a subsequent decrease in metabolism, which I have used in my study.

The question then arises as to whether the increase or reduction in

metabolism should be considered as the true effect of reduced pressure. Both are the direct result of this change of pressure and from that viewpoint both should be so considered. From the strictly theoretical viewpoint, it seems, a better definition of terms is desirable, since the reduced metabolism is the final and constant effect of reduced pressure. I would suggest that this should properly be called the reduced-pressure metabolism. The increased metabolism, on the other hand, since it is temporary, varying in amount with speed or degree of change of the conditions, should be called the reduced-pressure compensatory metabolism.

Summary.—Within ordinary ranges of temperature, 20 to 25° C, there is a "zone of comfort" in which standard metabolism is fairly constant. Above and below that point an "irritation metabolism" sets in which is physically recognized among honeybees by increased muscular activity and "fanning." At low temperatures, 10° C, for example, a numbing is experienced, with low metabolism as a consequence. Reduced pressure in the numbed condition in general reduces metabolism. Extremely low pressures bring in another factor, perhaps evaporation, which slightly increases carbon dioxide output. There is at first, in cases of reduced pressures, an increase in metabolism which later wears off. This may be called the "compensatory metabolism" after which the real reduced pressure effect reveals itself, which is found to be a reduced metabolism.—9-21-36.

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VACUUM FUMIGATION

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Although utilization of a vacuum in connection with the application of a gaseous insecticide is not new, it has been only within recent years that its development has increased markedly. The use of vacuum fumigation was originally discovered by Sasscer & Hawkins (*6*) in this country and Mackie in the Philippine islands. Experiments by Sasscer & Hawkins indicated that the fumigation of seeds by the introduction of HCN into an air-tight chamber from which the air had been practically exhausted is effective provided the exposure is not less than half an hour. Since that time much work has been done, and there is no doubt but that sustained-vacuum fumigation has advantages over the ordinary atmospheric fumigation.

Sasscer & Sanford (*7*) found that the effectiveness of HCN under the

[1] Paper 360, University of California Citrus Experiment Station and Graduate School of Tropical Agriculture, Riverside, Calif.

vacuum process is influenced by the water content of the soil. One hundred per cent kill was not obtained with larvae in soaked soil at dosages ranging from one-half ounce to 3 ounces of sodium cyanide per 100 cubic feet.

Smith (*8*) vacuum fumigated both brown-tail moth nests and European corn borer larvae with a dosage of 6 ounces of sodium cyanide to 100 cubic feet for two hours. The brown-tail moth larvae were killed when fumigated at 50° F, and in many cases when the temperatures were as low as 39° F. European corn borer larvae taken from a storeroom at a temperature of 40 to 45° F were not killed. He states, "I am forced to conclude that vacuum fumigation with a 6-ounce charge of cyanide is not effective against corn borers."

Back & Cotton (*1*) found that upon removal of air alone they were able to kill various species of insects, but a high vacuum had to be held for a long period of time, a procedure which is impractical in commercial work.

Mackie (*4*) found that adsorption of hydrocyanic gas by the load was greater as the vacuum increased. He injected HCN into vacuum of 5, 15 and 27 inches, and received the greatest adsorption of the gas at the highest vacuum. He states, "The difference between the initial pressure of injection and the ultimate pressure of exposure for fumigation has a considerable effect on the gas concentration, this effect increasing with the vacuum or largely with the departure from initial pressure."

Hagan (*3*) carried on tests to determine the resistance of pineapple planting material and its parasites to various dosages of gases applied in a vacuum fumigator. Three gases were tried: chloropicrin, carbon bisulfide and hydrocyanic acid, the latter giving the most satisfactory results.

Crumb & Chamberlin (*2*) found in the fumigation of cigars with HCN for the destruction of the tobacco beetle that sustained-vacuum fumigation was more effective than fumigation with dissipated vacuum.

Young, Wagner & Cotton (*10*) observed that the higher the initial vacuum the more efficient the fumigation. An initial vacuum of 26 inches gave poorer control than an initial vacuum of 28 or 29 inches. They also report that absorption of HCN gas by flour, as indicated by the gas remaining in the air, increases linearly with increase in vacuum.

Various fumigants have been advocated in conjunction with a vacuum, among these the two most common being hydrocyanic acid and carbon disulfide. The federal government employs HCN with a vacuum for the fumigation of baled cotton, but experiments by Turner & Sen (*9*) have shown that baled cotton can be fumigated successfully with HCN at atmospheric pressure. In California, vacuum fumigation with either HCN or CS_2 has been used extensively for the sterilization of nursery stock, stored products and field and truck crops. The question has arisen as to the relative merits of atmospheric, dissipated-vacuum and sustained-vacuum fumigation, and it was with this in mind that the following experiments were conducted.

Technic.—The work reported in this paper was carried on at the University of California Citrus Experiment Station in two vacuum

fumatoriums which have been described by Quayle (*5*). The temperature range at which these tests were conducted varied between 70 and 75° F with the vast majority of them being made at 73° F. The insect used was the convergent lady beetle, *Hippodamia convergens* Guerin, obtained from hibernating colonies in the nearby mountains.

From 30 to 40 insects were placed in 1-inch square wire cages. Checks held under atmospheric conditions showed no mortality, while 6 per cent of those beetles held at a vacuum for one hour died. All exposures were for one hour. In the first series of experiments the cages were hung in various parts of the empty fumatorium. In series 2 and 3, a cage with insects was placed in a sack of soil in such a manner that the insects were 2 inches from any surface of the muslin container. In other words, the HCN gas had to pass through 2 inches of soil before it reached the lady beetles. In series 2 the soil was dry, while in series 3 the soil was moist. In the fourth series 75 boxes filled with excelsior were placed in the fumatorium. These boxes are the containers used by the Calavo Growers for packing avocados. The insects in cages were placed in the excelsior in certain marked boxes which were distributed throughout the fumatorium. In the final series of experiments the cages with insects were placed in the center of a rolled bundle of 50 empty burlap sacks. Only one bundle of these sacks was placed in the fumatorium during a fumigation.

Commercial liquid HCN (96 to 98 per cent) was used. In the experiments carried out at atmospheric pressure, the HCN was measured into the fumatorium and the circulating fan allowed to run for one minute at five-minute intervals. The sustained-vacuum experiments were conducted as follows: The insects were placed in the fumatorium and a vacuum of 27 inches was obtained. The hydrocyanic acid gas was then measured into the fumatorium and enough air allowed to reduce the vacuum to 26.5 inches of mercury. At the end of the hour the vacuum has usually fallen to about 23 inches. The dissipated-vacuum experiments were carried on in a similar fashion except that after the HCN was measured into the fumatorium air was allowed to enter until the pressure within the fumatorium was equal to atmospheric, which was about 28.5 inches. This usually took about five minutes, but the length of the exposure was always measured from the time the fumigant was applied.

In an empty fumatorium in which penetration of the fumigant is not a factor, there is no decided advantage in dissipated-vacuum fumigation over atmospheric fumigation, but sustained-vacuum fumigation is more effective than either dissipated or atmospheric fumigation.

When the insects are buried in dry soil sustained-vacuum fumigation shows a very decided advantage over either dissipated-vacuum fumigation or atmospheric fumigation. Under these conditions, sustained vacuum is at least four to five times more efficient than dissipated vacuum, and eight to 10 times more efficient than atmospheric fumigation. The dosage required under sustained-vacuum fumigation to kill 100 per cent of the beetles buried in dry soil was no greater than when the insects were placed in the empty fumatorium. The dosage of HCN required

under atmospheric and dissipated-vacuum fumigation to kill 98 to 100 per cent of the insects was much greater, five or more times than that used to obtain the same kill of insects in cages in the empty chamber.

Table 1.—Results of fumigation against *Hippodamia convergens* with liquid HCN.

Cc. of HCN	Percentage of Insects Killed		
	No Vacuum	Dissipated Vacuum	Sustained Vacuum
Insects in Cage in Empty Fumatorium			
1			94.8
2	47.9	87.	95.3
3	77.	98.6	98.4
4	95.	98.2	100.
5	97.6	100.	100.
6	97.9		
Insects Buried in Sack of Dry Soil 2 Inches from Any Surface			
2			96.
3			99.3
4			100.
5			100.
8	19.	63.4	
10	81.7	35.5	
12	81.	91.9	
15	85.5	98.9	
20	94.1	100.	
25	99.3		
30	98.5		
35	99.1		
Insects Buried in Sack of Moist Soil 2 Inches from Any Surface			
5			83.7
8			97.1
10			100.
15	0.	6.6	
20	20.9	2.6	
25		40.2	
30	20.9	37.3	
35		82.8	
40	87.4		
Insects in Cages Inside Boxes of Excelsior; 75 Boxes in Fumatorium			
10			
15			97.8
20		95.7	100.
25	97.9		
30	100.		
Insects in Cages Buried in the Center of a Rolled Bundle of 50 Burlap Sacks			
25			94.9
35			98.8
50	1.9	13.	99.1
75	4.	46.6	98.6
100	4.4	26.4	
120	0.	30.3	
150	0.		

From table 1 it is observed that with the insects buried in wet soil the same relationship exists between sustained-vacuum, dissipated-vacuum

and atmospheric fumigation that obtained when dry soil was used; that is, sustained-vacuum fumigation is by far the most efficient. The results with no vacuum and dissipated vacuum were very irregular, dissipated-vacuum fumigation being little better than no vacuum. It will also be noticed that a much higher concentration of HCN is required to penetrate wet soil than dry soil.

Although there are differences between sustained-vacuum, dissipated-vacuum and atmospheric fumigation, they are not as outstanding as when the insects are placed in boxes loosely packed with excelsior. In this case, adsorption of the fumigant is as important a factor as penetration.

Satisfactory fumigation of burlap sacks seems to be rather difficult, especially if the sacks are bundled together. With a dosage of 75 cc. per 100 cubic feet in a vacuum there were a few insects that survived, while at 150 cc. with no vacuum there was no kill of lady beetles.

Summary and conclusions.—A study of atmospheric, dissipated-vacuum and sustained-vacuum fumigation was made to determine the relative value of each.

In an empty fumatorium where penetration of the fumigant is not a factor, atmospheric fumigation is almost as efficient as dissipated vacuum, but neither is as effective as sustained-vacuum fumigation.

When penetration of the fumigant into soil, burlap sacking, etc., is required, sustained-vacuum fumigation is much more effective than either atmospheric or dissipated-vacuum fumigation. The difference between dissipated-vacuum and atmospheric fumigation is not so great.

A higher concentration is required to penetrate moist soil than dry soil.

When both adsorption and penetration to some extent have to be considered, the difference between atmospheric, dissipated-vacuum and sustained-vacuum fumigation is not so great as when penetration is the only factor to be considered.—9-21-36.

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FIELD METHODS FOR INVESTIGATION OF CODLING MOTH INSECTICIDES[1]

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Increased difficulties in codling moth control and spray residue removal have recently stimulated research activity in insecticides. Reports of investigators in this field commonly show surprising diversity of opinion concerning the effectiveness of almost any insecticide that has been examined—even that usual standard of comparison, acid lead arsenate. Much of this lack of uniformity is to a large degree attributable to climatic variations in different apple-growing regions, to variations from year to year in the same region, and to the necessity or lack of necessity for fungicides and the like. Nevertheless, investigators operating in the same general area frequently report what appear to be totally different results from the same spray material.

At present there prevails a variety of plans for the study of codling moth insecticides. Sometimes these are the casual methods of five or 10 years ago and sometimes they follow closely the tenets of the statistician, since recently some little emphasis has been given the application of certain forms of statistical analysis to the problems of codling moth infestation.

Concerning methods.—It is common practice to divide an orchard into a number of plots, each sprayed with a different material, a few of which plots serve as checks. Sometimes only a single check plot is provided. Such an arrangement may give very misleading results, as is illustrated by fig. 1. This chart represents a 12-acre experimental tract of the Washington Experiment Station in 1934. It consisted of one 6-acre block of Jonathans and one of Romes sprayed in previous years by the owner and considered fairly representative of the general run of orchards in the district.

Each small rectangle represents a six-tree plot, the figures being the numbers of worms per 100 apples in the series of 30 check plots, all of which had been sprayed with lead arsenate, 3 pounds to 100 gallons of water. Each experimental plot immediately adjoined a check plot but to avoid complicating the chart no infestation is indicated for the experimental plots. The experimental treatments were applied to two plots, one Jonathan and the other Rome. These were sprayed simultaneously, two men working on each variety. A fifth man attended to the mixing of sprays.

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Each tree was sprayed throughout the season by the same man, who was guided by a card giving the nature of the mixture to be applied to each plot. Field telephones, signals tapped on the overhead pipe system and observation of the overflow at the spray plant enabled the two pairs of spray men to keep in touch with one another and with the man preparing the mixtures at the spray shed. Each knew when the others had finished their trees, when water was being sent through to flush the lines, when the new material was coming and how to distinguish it. Experimental treatments were applied within one-half hour of the time the adjoining check treatment was applied.

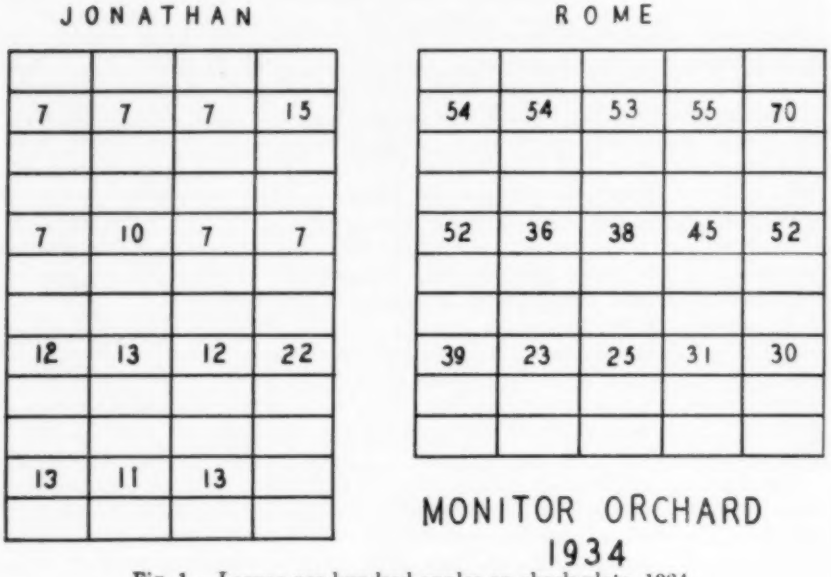

Fig. 1.—Larvae per hundred apples on check plots, 1934.

The man mixing the sprays checked off the addition of each ingredient on small index cards inserted in holders on the sides of the spray tanks. These cards, one for each plot, gave the necessary amounts of all substances indicated and had space for date of application and the quantity of spray liquid used.

Bearing in mind the precautions that were taken to insure uniformity and accuracy in the application of sprays, the infestation at harvest as measured by the check plots showed great fluctuation of population in different parts of the orchard. The Jonathan check plots varied from seven to 22 worms per 100 apples; the Romes varied from 23 to 70, each variation within the compass of 6 acres. Chemical analyses indicated that the spray deposits on these plots were reasonably uniform within the variety so that the differences in infestation must be attributed to causes apart from the quantity or type of poison adhering to the fruits.

Referring to the common practice of having only occasional check

plots in an experimental block and attempting directly to use these as a basis for the comparison of experimental materials, let us suppose there had been only 10 check plots in this orchard. Then some of the experimental treatments would have been removed by as many as six rows from the nearest check plot. If comparisons were made to the nearest check, infestation differences of over 100 per cent would have occurred solely as a result of the location of the plots. If comparisons were made to the average infestation of the five check plots for each variety, then, as in the case of one random selection for Jonathans, an average check infestation of 11 worms per 100 fruits might have served as a basis of comparison for one plot with 22 worms and another with seven worms when as it so happened these two plots were sprayed with the same material. Obviously this type of arrangement and comparison is unsuited to these conditions. Nevertheless, they are ostensibly those of an "average" experimental orchard.

The writers used the following plan in estimating the effectiveness of the experimental mixtures represented by the blank rectangles in fig. 1. First a map of the plots was made, then the codling moth infestation was zoned by means of the numerous check plots. Next, assuming the intervening experimental plots had been checks, theoretical infestations were interpolated. The actual infestation for each experimental plot was then compared with the interpolation. If it was decidedly lower, the experimental treatment was considered probably better than the check; if decidedly higher, probably inferior.

After the experimental treatments had been tentatively estimated in this way, a second comparison was made. Each experimental plot was compared to the adjoining check plot, using the formula $\frac{x-y}{x} \times 100$ = percentage relationship,[3] where x = number of worms per 100 fruits for the check plot and y = the number for the adjoining experimental plot. From the result was subtracted the estimated experimental error. If a positive percentage relationship remained, the experimental treatment was regarded as probably better than the check adjoining; if a minus percentage, as probably inferior. The experimental error was estimated by comparing each check plot with an adjacent check plot using the same formula.

The final step was to compare the rankings of the experimental treatments obtained by the two methods. In every case they agreed and in a broad way this held for both varieties. The necessary calculations were quickly made once the infestation records had been assembled. More detailed study of the data was considered unjustified for it has been the experience at Wenatchee that time spent in the chemical laboratory or library has been more productive than that spent on laborious calculations dealing with codling moth infestations. Experience further indicates that only large differences should be considered and in the case of recommendations concerning distinctly new spray mixtures such differences should be reproducible over at least a three-year period, particu-

[3] This formula is not entirely satisfactory. It exaggerates differences at low levels of population; but since adjacent check plots are similarly compared, the estimated experimental error is correspondingly greater.

larly because of the potent effects of variations in weather conditions from year to year.

In the last four years this station has made use of four different orchards and three different stationary sprayers. Because of these circumstances and irregularity in the cropping of various varieties, although eight experimental layouts have been used, no two have been alike. For instance, the method previously described was apparently satisfactory

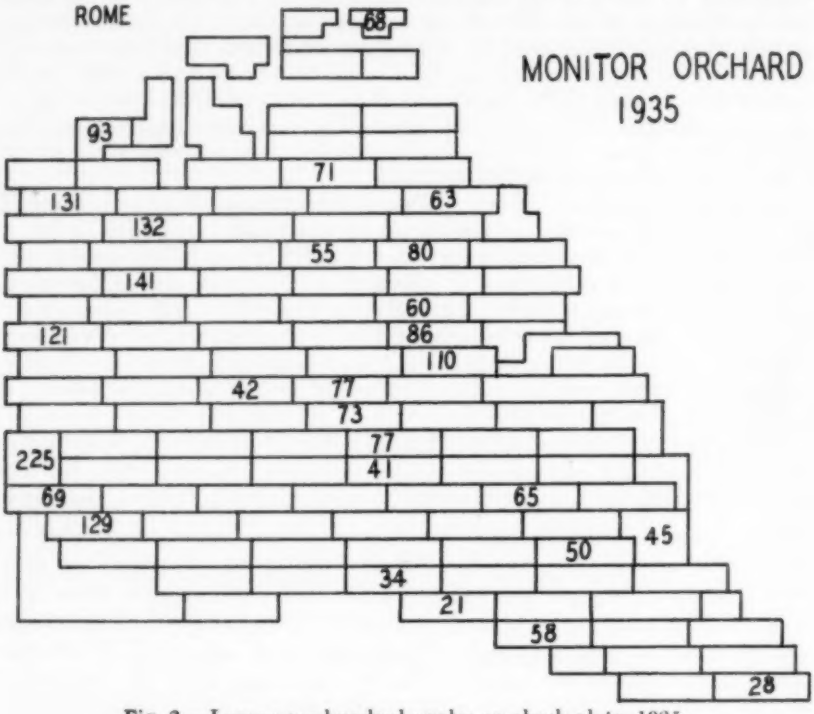

Fig. 2.—Larvae per hundred apples on check plots, 1935.

for one orchard in 1934 but it could not be applied in 1935, because the block of Jonathan trees did not bear a commercial crop. An additional and adjoining 6-acre block of Romes was substituted, giving a 12-acre experimental orchard of one variety. The owner had removed half the trees during the winter of 1934–35, which was an additional complicating factor since the remaining trees could not be arranged in six-tree plots because of the unsuitable locations of spray lines and spigots. An entirely different arrangement of plots was used, as shown in fig. 2.

In 1935 the 24 experimental treatments were applied to plots of three trees. The plots were replicated four times, a layout, which because of the shape of the orchard, resulted in what might loosely be called a modified restricted-random arrangement. Seven checks spaced at intervals each consisted of four replicates, a total of 28 check plots.

In each of the four series of plots, the plots always followed one another consecutively. This is, of course, a weak point in the arrangement but it brings out the need for flexibility in the form of the layout. Had a true restricted-random arrangement been followed there would have been considerable reduction in the amount of work accomplished because of the extra labor involved in changing spray hoses.

At harvest the average infestation as worms per 100 fruits for the four replicates of each experimental plot was determined; then the seven check plots (four replicates each) were averaged in the same way. The average deviation from the mean infestation of the check plots was then taken as a rough indication of the experimental error, which in the instance largely because of a scattered crop was very high—22.7 worms per 100 apples.

For the present year (1936) a rather limited amount of work is being done with codling moth at this station because only 4 acres of mixed varieties are available. The problem of plot arrangement is quite different from that of any time previous so that an entirely new plan is being followed. Emphasis will be placed on numerous deposit analyses[4] rather than on infestation, for it has been ascertained at Wenatchee that at least within certain limits codling moth control can be predicted for a given arsenical if the qualitative and quantitative nature of the toxic deposit have been accurately determined and providing no substance has been added which will affect toxicity. This may appear to contradict a previous statement in which great variation in infestation of check plots was ascribed to factors other than the arsenical load. However, as a matter of fact, not until this variation was demonstrated did it become possible to place reliance on chemical determinations. Like deposits were found to give like control but only after the experimental error had been taken into account.

As previously mentioned, a considerable amount of attention has been given the application of statistical analysis to these problems during the last four or five years. Benefits are already appearing in the increasing care with which plot arrangements are being studied and data interpreted. Yet even today attempts are made to evaluate experimental mixtures based on materials of unknown composition (very often proprietary products of which the trade names may indicate one thing this year and an entirely different thing next). Frequently no consideration is given the chemical determination of spray deposits, although the amount of a substance introduced into a spray tank may not give any indication of the amount that adheres to the fruit surface. However, that is an all-important point in codling moth control.

Many reports of codling moth investigations disregard the question of experimental error, yet it is frequently far greater than variations resulting from differences in spray materials. There have been instances where unreplicated plots were laid out with no apparent thought of estimating the experimental error. Every apple was checked at harvest under the evident assumption that if every worm is accounted for, the records must

[4] For method of analysis see Groves, Kermit & J. Marshall. The determination of spray coverage on apples Jour. Ag. Res. 51(12):1139–42.

be reliable. Incidentally it has been determined that if the sampling is done carefully there is no necessity for checking more than about 300 apples per tree to obtain a reasonably accurate estimate of infestation.

The more recent statistical work seems to be doing much to remove any impression that mathematics can be substituted for sound planning and thorough work. But on the other hand, there may be such a straining for the ideal that in order to have a plot arrangement which fully meets the requirements of the statistician other considerations are put aside. Under the circumstances usually prevailing in orchard experiments a compromise seems necessary between the purely statistical point of view and the rule-of-thumb methods so general in the past. This has been the trend in the Wenatchee codling moth investigations.

General procedure in the Wenatchee investigations.—In examining new spray materials at the Wenatchee laboratory the following steps are generally followed:

(1) Laboratory spraying experiments are conducted at 300 pounds per square inch with special equipment capable of operating on small amounts of liquid, and quantitative determinations are made of the spray deposits. (Low-pressure equipment operated by compressed air has not been satisfactory.)

(2) Mixtures capable of producing deposits satisfactory both qualitatively and quantitatively, and which are considered probably innocuous to foliage or fruits, are applied to two trees of different varieties by a two-gun stationary sprayer. Materials considered probably injurious to foliage are applied to individual limbs only.

(3) Substances not eliminated on the basis of either toxicity to trees or very evident lack of effectiveness for codling moth control are applied the following year to larger replicated plots by a four-gun sprayer.

(4) Mixtures are eliminated which, even though high deposits were obtained, gave control evidently definitely inferior to the check after allowing for the estimated experimental error. Those with low deposits and with inferior control or which caused injury are either (a) eliminated or (b) changed somewhat as to the amount or character of an ingredient and are applied again with the heavy equipment the next year. Those which have given satisfactory deposits and satisfactory control and which have not caused injury are applied a second year.

(5) Mixtures having continued to give suitable experimental results for the second year are applied a third year.

(6) After three years of satisfactory results, mixtures are given to reliable growers for small-scale experimental applications. If the general report of the growers is favorable the material may then be suggested to the industry for limited use the following year.

This general procedure has been followed since 1933 and this year two calcium arsenate mixtures out of approximately 100 examined are being suggested for trial to a small number of interested growers. In the case of experiments dealing with spreaders or stickers for lead arsenate much less detail has been necessary. A number of recommendations concerning such substances have been made after only one year of experimental work.

For the last several years very little time has been spent on "split" spray schedules; that is, the use of one insecticidal ingredient for one or more applications followed by another for one or more applications. The feeling has been that even if a particular material has been used throughout the season, or for that matter for two or more successive seasons, there are sufficient unavoidable sources of variation to complicate its evaluation without introducing an additional one. A split spray schedule has been employed only as an ultimate refinement. Indeed, adjustment of the various types of spray mixtures within spray schedules has been left largely to the grower and production man. Once the effectiveness and characteristics of a mixture have been determined its future use depends to a large measure on a number of factors which vary seasonably and according to individual orchards or districts.

Presentation of results.—In making routine reports of the Wenatchee investigations the aim has been to include sufficient detail so that other investigators in the same field could if they wished repeat the work and compare results on a common basis. Little attempt has been made to draw conclusions in these accounts of seasonal progress. Others should be more satisfied to interpret the results for themselves. This can be done quite readily when sufficient data are given although these need be only in barest outline. Such considerations were in evidence in the annual report of the Washington Experiment Station to the Western Spray Conference for 1935 in which the following was provided:

(1) A map of the experimental orchard giving infestation by plots.

(2) Analyses and sources of all spray materials.

(3) Average of four to five duplicated arsenical deposit analyses (as micrograms As_2O_3 per square centimeter) for every plot including check plots and including two varieties.

(4) Maximum, minimum and average deviations from the mean deposit of the check plots.

(5) Average worms per 100 fruits for all plots and for each variety.

(6) Maximum, minimum and average deviations from the mean worms per 100 fruits for the check plots.

(7) A brief note on the qualitative nature of the spray deposits.

(8) A brief note on any visible injury to trees.

(9) Statement of method used in determining arsenical deposits.

(10) Number of spray applications and quantity of spray applied per tree.

Although these items may suggest a great deal of compilation, all the information is necessary before the reader can logically interpret the results. As a matter of fact, when the deposits have been calculated and the infestations determined, the rest requires comparatively little time.

Discussion.—The foregoing remarks may be summarized thus: First, since orchards have not been set out for the express purpose of plot arrangement, it seems neither desirable nor necessary to lay down definite rules for such arrangement. Nevertheless, some general principles must be observed in order that experiments may follow the scientific method. Where there is particularly acute need for information concerning improved spray mixtures, usually the important consideration is to cover

as much ground as possible and still obtain tolerably accurate information. Under ordinary circumstances, at least, it seems advisable to vary investigational details to suit the rather constantly changing features peculiar to codling moth problems. Small differences in the results should be considered due to chance. If an experiment has been carefully planned, significant differences should be readily detected without recourse to a very detailed analysis of the data.

Second, close cooperation between chemist and entomologist is essential. Spray deposits should be determined quantitatively whenever possible for upon the extent of the deposit may rest intelligent elimination or improvement of an insecticidal mixture. Furthermore, it is frequently necessary to analyze the chemicals that are used to be certain that the work may be accurately repeated if necessary.

Third, the use of split spray schedules has not been profitable except for the ultimate refinement of proved mixtures and this generally can be done as necessary for particular conditions once the advantages and limitations of such mixtures are known. This generalization would not always apply in districts where combined insecticide-fungicide mixtures are necessary or where mites must be combated.

Fourth, the experimental use of propietary materials should be strictly avoided, unless their composition is known and can be stated. Trade names do not necessarily indicate uniform composition from year to year.

Fifth, in the presentation of results sufficient detail should be included so that one unfamiliar with the work may make his own interpretation and be able to repeat the experiments accurately should he so desire.—9-15-36.

THIODIPHENOLAMINE—A NEW INGREDIENT OF MOSQUITO LARVICIDES[1]

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Thiodiphenolamine, or phenothiazine as it is also known, is a milky green rhombic substance with the formula $S(C_6H_4)_2NH$ and a molecular weight of 199.14. It is very soluble in benzene and acetone, soluble in ether and slightly soluble in alcohol. This material has been considered in recent months as an insecticide against fruit-tree pests, and certain preliminary experiments have been carried out at the Montana experiment station to test its value as an ingredient in mosquito larvicides.

Thiodiphenolamine as a larvicide was first tried out by the writer in a field laboratory during the summer of 1935. In the initial experiments it was used as a dust, as a dust diluted with 95 per cent road dust, and added to kerosene spray. In these initial experiments only 10 larvae were used in stender dishes. Table 1 gives some typical results.

This initial work showed that the thiodiphenolamine was not as lethal

[1] Contribution from Montana State College Agricultural Experiment Station, paper 75, Journal series

in its action on mosquito larvae as was either the road-dust mixture or the kerosene mixture. Many more preliminary tests were run, thiodiphenolamine in various combinations being tested against kerosene, lubricating oil, crank-case drainings and diesel-engine fuel oil, and in every case the addition of thiodiphenolamine (TDPA) resulted in a more toxic product.

During the six weeks covered by these tests the opportunity was afforded of making some tests in natural breeding places. Rainfall was chiefly in the form of thunder showers, and following such precipitation every depression in the prairie was filled with water. In the larger depressions the pools remained sufficiently long to allow myriads of mosquitoes

Table 1.—Initial experiments with thiodiphenolamine as a larvicide. Started at 11:30 a. m.

Dish	Material	Percentage Larvae Dead at							
		1:45 p. m.	4:45 p. m.	5:45 p. m.	6:45 p. m.	9 a. m.	11 a. m.	1:30 p. m.	4 p. m.
1	Check (water)				10	10	10	10	10
2	1 drop kerosene		10	10	20	30	30	30	30
3	Thiodiphenolamine		30	30	100				
4	Thiodiphenolamine 1 drop				90	100			
5	Thiodiphenolamine and kerosene	20	100						
6	2 drops kerosene	60	70	70	70	70	70	70	70
7	2 drops thiodiphenolamine and kerosene	100							
8	Thiodiphenolamine 5%, road dust 95%	10	100						
9	Thiodiphenolamine 5%, road dust 95%	20	100						
10	Thiodiphenolamine 5%, road dust 95%		80	80	100				

to mature, usually about eight days. In these pools, as in the laboratory, observations showed again the superiority of oils with thiodiphenolamine added compared with the same oils without this material. This applied only to larvae. Against pupae no increase in lethal effect was noted.

During the winter months more exact tests were continued at Bozeman. Through the courtesy of Dr. W. V. King an abundant supply of material was available from Florida. Thiodiphenolamine in combination or alone, was tested with about 50 other larvicides. Diesel-engine oil, furnace fuel oil and crank-case drainings were finally concentrated on. When added directly to these oils thiodiphenolamine did not completely dissolve. Apparently, however, the toxic element in the thiodiphenolamine was soluble, since the supernatant liquid after an oil–thiodiphenolamine mixture had stood for 24 hours was just as toxic as the freshly made and constantly agitated mixture. Thiodiphenolamine dissolved in acetone and this added to an oil, produced a mixture that was no more toxic than the supernatant liquid referred to above.

No tabular data are included here for tests with crank-case drainings. This material is not considered a suitable larvicide for use under Montana conditions because of its poor spreading qualities, its lack of toxicity and its variability in composition. Its chief merit lies in its cheap-

ness and availability. Addition of 5 per cent cresoap improved its spreading qualities and the further addition of 1 per cent thiodiphenolamine greatly increased its toxicity. Nevertheless on account of its lack of uniformity in composition, crank-case oil was discarded and diesel fuel oil substituted. Tables 2 and 3 show how the addition of thiodiphenolamine markedly increased the toxicity of diesel oil.

Table 2.—Comparison of toxicities of diesel oil and diesel oil–thiodiphenolamine. Experiment 32, started at 10:45 a.m. with 100 larvae to each dish.

Dish No.	Surface Area, Sq. Cms.	Material	Cc. Used	Per Cent Dead at 1:30 p. m.	3 p. m.	4 p. m.	10 a. m.
1	800	Diesel oil	.5	1	9	16	66
2	721	Diesel oil +5% acetone solution of TDPA	.5	22	60	88	99
3	804	Diesel oil +3% acetone solution of TDPA	.5	18	67	83	98
4	725	Diesel oil +1% acetone solution of TDPA	.5	14	35	53	92

Comparison was made between a freshly mixed suspension of thiodiphenolamine in diesel oil and the supernatant liquid from a similar mixture that had stood for 24 hours, table 3.

It would appear from the results shown in table 3 that there is little difference over a period of several hours between the supernatant liquid and a fresh suspension of diesel oil and thiodiphenolamine. These results, however, may have a practical significance as a suspension would probably, in the absence of adequate agitation, vary in strength, and again there would be the possibility of a clogging of the nozzles of the spray guns, difficulties that would be obviated by using an oil without suspended matter.

The addition of even a small amount of thiodiphenolamine to diesel-engine oil increases its toxicity to a noticeable degree, as was shown also in table 2.

Table 3.—Comparison of toxicities of freshly mixed thiodiphenolamine–diesel oil, and mixture of same 24 hours old. Experiment 25, started at 10:45 a.m. with 100 larvae to each dish.

Dish No.	Surface Area, Sq. Cms.	Material	Cc. Used	Per Cent Dead at 11:45 a. m.	1:45 p. m.	2:45 p. m.	3:45 p. m.	4:45 p. m.
5	800	Diesel oil alone	.3	6	10	22	40	55
1	800	Supernatant liquid from 100 cc. diesel oil +.5 grams TDPA	.3	47	89	98	99	100
2	721	Fresh suspension of 100 cc. diesel oil and .5 grams TDPA	.3	21	67	84	90	97

Conclusions.—From these preliminary observations it appears possible that the addition of thiodiphenolamine to a mosquito oil will, by increasing its toxicity, enable economies to be made in the quantities of oil necessary to cover a given area without the sacrifice of efficiency. —9-21-36.

Recent revision of the California quarantine relating to the peach mosaic disease in that state adds four townships in San Diego county to the area designated as infested. Parts of Riverside and San Bernardino counties are also declared to be infected.

EFFECT OF SEVERAL VARIETIES OF SORGHUM AND OTHER HOST PLANTS ON BIOLOGY OF THE CHINCH BUG

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For several years the effect of chinch bugs, *Blissus leucopterus* (Say), feeding on several sorghum varieties has been studied at the United States Department of Agriculture's Dry Land Field Station, Lawton, Okla., in cooperation with the Kansas Agricultural Experiment Station. These studies have shown that the milos are very susceptible, that the feteritas are susceptible, but that the kafirs and sorgos are, in general, rather resistant. In 1935 experiments were planned at Lawton in cooperation with the Department of Entomology, Oklahoma Agricultural Experiment Station, to study the effect of different varieties of sorghum and other host plants on the biology of the chinch bug. The highly susceptible Dwarf Yellow milo (C.I. 332) was selected as a typical variety of the milo group. Common feterita (C.I. 182), which is slightly less susceptible than Dwarf Yellow milo under field conditions, represented the feterita group. Blackhull kafir (C.I. 71) was used as the typical kafir variety. Atlas sorgo (C.I. 899), a highly resistant variety, was used as a representative of the sorgo group. Other plants used were Manchuria barley, Hays Golden corn, Kanota oats, Turkey wheat, Sudan grass, and Johnson grass.

Oviposition and longevity of adults.—The first experiments were planned to determine the effect of plant variety in the seedling stage on the longevity of the adult females, preoviposition and oviposition periods, and total number of eggs laid. The experiments were conducted in a room where the average daily temperatures throughout the summer ranged from 68 to 89° F with a mean of 80° F. The cages consisted of transparent celluloid tubes open at both ends, about 70 mm. long and 25 mm. in diameter. One end of the tube was stoppered with cotton and the other end closed with the large end of a tight-fitting split cork. Seedling plants five to six days old were used as food except for Johnson grass, in the case of which shoots from older plants were used. These plants were taken from the soil and placed between the halves of the cork with the roots extending below and the leaves above. The small end of the cork was then inserted in a shell vial that was almost full of water, so that the roots were immersed. The plants were changed daily, and at this time egg counts were made. The water in the vials was changed once a week. A pair of chinch bugs was placed in each cage; the male was replaced if it died, whereas when a female died the experiment was discontinued.

It was found that overwintered females colonized on Dwarf Yellow milo seedlings laid more eggs, had a higher daily rate of oviposition and

lived longer than those caged on Atlas sorgo seedlings. These bugs were collected from a barley field and had probably laid some eggs before they were placed in the cages. The 12 females that fed on Atlas sorgo laid 51 eggs, or an average of only 4.25 ± 3.89 eggs for each female. Three of these females laid no eggs. The largest number of eggs deposited by any one female that fed on Atlas was 22 during a period of 28 days. The average length of life of these females was 8.5 ± 4.45 days. Two of them died within two days after being placed on Atlas, while one lived as long

Table 1.—Oviposition and longevity of first and second generations of chinch bugs on 10 host plants, Lawton, Okla., 1935.*

Host Plant	No. Females Laying Eggs	Av. Preoviposition Period, Days	Total No. Eggs Laid	No. Eggs Laid per Female		Av. No. Eggs Laid per Day	Longevity, Days	
				Range	Average		Average	Range
First Generation								
Johnson grass	10	13.9± 2.5	1378	13–289	137.8±65.5	3.5	53.5±16.2	18–96
Dwarf Yellow milo	10	6.9± 1.8	1179	65–234	117.9±33.7	3.5	40.2± 6.2	30–59
Barley (Manchuria)	10	13.8± 2.8	524	19–131	52.4±19.4	1.7	43.8± 8.	33–78
Blackhull kafir	8	13.2± 3.6	219	0–82	21.9±17.	1.3	29. ± 8.8	6–43
Corn (Hays Golden)	8	19.7± 4.8	114	0–34	11.4± 7.6	.5	44. ±14.2	11–88
Oats (Kanota)	4	9. ±11.4	58	0–27	5.8± 5.7	.4	24.4±11.7	6–50
Sudan grass	7	7.7± 1.4	42	0–11	4.2± 3.	.4	17.3± 6.3	6–32
Wheat (Turkey)	3	9.7± .3	21	0–10	2.1± 2.5	.4	15.2± 7.	6–39
Atlas sorgo	4	15.2± 2.9	9	0– 3	.9± .8	.2	15.3± 6.	4–33
Feterita	0		0				15. ± 4.	9–25
Second Generation								
Johnson grass (4)†	10	7.2± .7	1298	61–184	129.8±25.4	2.	70.6±16.8	37–100
Dwarf Yellow milo (7)	9	10.4± 4.5	528	0–117	52.8±23.9	.8	73.9±26.8	9–100
Barley (Manchuria) (5)	10	13.7± 3.6	211	4– 69	21.1±12.8	.4	67.2±23.2	9–100
Blackhull kafir	4	12.5± 2.	110	0– 46	11. ±11.	1.3	20.6± 8.1	8– 43
Corn (Hays Golden) (1)	9	12.6± 2.7	95	0– 27	9.5± 5.5	.4	37. ±16.2	16–100
Sudan grass	5	10.6± 2.	20	0– 8	2. ± 1.9	.2	20.1± 7.7	11– 48
Wheat (Turkey)	2	12. ± 4.	17	0– 14	1.7± 2.8	.6	12.6± 4.5	8– 29
Oats (Kanota)	3	13. ± 2.5	10	0– 8	1. ± 1.6	.6	13.3± 4.2	8– 30
Atlas sorgo	1	5.	1	0– 1	.1	.3	8.8± .8	7– 11
Feterita	0		0				9.4± 1.8	8– 17

* Ten pairs of bugs were used with each host plant.

† Numbers in parentheses indicate number of pairs alive on November 18, when the experiment terminated

as 28 days. The 14 females on Dwarf Yellow milo laid a total of 1027 eggs, or an average of 73.3 ± 37.7 eggs for each female. All these females deposited some eggs; 10 of them laid more than 22 eggs each, the most recorded for any female feeding on Atlas. The largest number of eggs laid by any female feeding on Dwarf Yellow milo was 184, which were deposited over a period of 46 days. The average length of life of the females that fed on Dwarf Yellow milo was 23 days. Six females were still alive on Dwarf Yellow milo after the last female on Atlas had died.

Further studies, in which 100 females were used, proved that the biology of first-generation bugs was also greatly influenced by the variety or species of host plant upon which they were colonized. The insects were collected when in the fifth instar while migrating from a barley and wheat nursery into the sorghum-breeding nursery, and caged on Dwarf Yellow milo in the laboratory until they had reached the adult stage. The 10 varieties of plants previously mentioned were used as hosts. One pair of bugs was confined to each cage, and there were 10 cages of each variety or species of host plant under test. All the females had reached

the adult stage on the same day, and the experiment was conducted under comparable conditions except for the difference in food plants.

The results which are given in table 1 show that all 10 of the females caged on Johnson grass, Dwarf Yellow milo and barley laid eggs, whereas none of those feeding on feterita, a susceptible variety under field conditions, oviposited. The shortest preoviposition period was two days for a female on Dwarf Yellow milo, and the longest 28 days for a female feeding on corn. Females that fed on Johnson grass ranked first in total number of eggs laid and in average length of life, one depositing 289 eggs over a period of 82 days. Females caged on Dwarf Yellow milo ranked second in total number of eggs laid and fourth in average longevity.

Studies concerning oviposition and longevity of 100 second-generation females showed essentially the same results as were recorded for

Table 2.—Rate of development of chinch bug nymphs reared on Dwarf Yellow milo and Atlas sorgo seedlings, Lawton, Okla., 1935.

Stadium	Average Duration of Stadia, Days					
	First Generation		Second Generation		Third Generation	
	Dwarf Yellow Milo	Atlas Sorgo	Dwarf Yellow Milo	Atlas Sorgo	Dwarf Yellow Milo	Atlas Sorgo
First	12.6± .9	13.4± .9	13.3±1.4	15.6±1.7	19.2±3.1	23.3±5.7
Second	4.8± .7	5.6±1.3	6.7±3.2	9.4±7.3	6.9± .8	10.2±4.2
Third	5.5±1.	6.6±1.8	7.4±3.5	10.7±5.5	7.4±1.5	11. ±2.9
Fourth	5. ±1.	9.2±2.5	6.7±2.5	14.5±3.7	8.4±1.1	14. ±4.7
Fifth	7.7±1.2	13.2±3.6	13.1±3.9	*	14.3±1.7	*
Average	7.1	9.6	9.4		11.2	
Average† No. days from hatching to adult	35.34±1.9	45. ±3	44.69±8.9		56. ±4.2	
Range	30–40	40–50	27–72		45–67	

* All dead before reaching adult stage.
† Weighted average.

those for the first generation. Table 1 shows these data up to November 18, 1935. This experiment was conducted in the same manner as that for the first generation in regard to the host plants tested and number of bugs used. The insects were collected in the field from headed plants of Spur feterita when in the fifth instar, which was six days before they reached the adult stage. These fifth-instar nymphs were placed on their respective hosts as soon as collected instead of being reared on a common host, as was done in the case of the first-generation nymphs. This change in technic may explain the marked reduction in the average length of life of the second-generation females observed on some of the resistant varieties, as compared with longevity of those of the first generation feeding on the same varieties. For example, the average length of life of first-generation females on Atlas sorgo was 15.3 ± 6 days, while for the second-generation females it was only $8.8 \pm .8$ days. Actually, however, second-generation females lived on Atlas sorgo for an average of 14.8 days, six days in the fifth instar and 8.8 days in the adult stage.

The duration of the oviposition period and the longevity of second-generation females were similar to those of the first generation, oats being the only host plant that changed rank in its effect on the biology of the chinch bug. The total number of eggs laid by females caged on oats was 10, thus shifting it from sixth to eighth place in rank as a host plant. All the females that fed on feterita died without laying eggs, as in

the first-generation studies. The females that fed on Johnson grass again ranked first for total number of eggs laid, but those on Dwarf Yellow milo lived the longest. On the other hand, Atlas, a resistant variety of sorghum, did not sustain life as long as the other nine host plants used.

Rate of development, mortality and body length of nymphs.—Nymphs hatched from eggs that were laid on Dwarf Yellow milo plants in the laboratory were used in this experiment. The adult bugs that laid these eggs had previously been collected from a field of barley. The eggs were not saved for nymphal study until the adults had fed at least one week on Dwarf Yellow milo. As soon as the eggs were laid they were removed from the plant, and the nymphs hatching therefrom were transferred directly to the test seedlings, Dwarf Yellow milo, a susceptible variety,

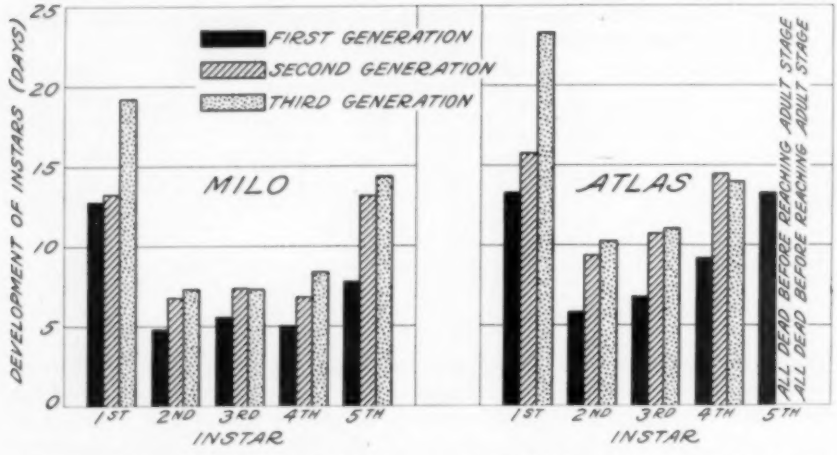

Fig. 1.—Rate of development of first, second and third generations of chinch bug nymphs reared on seedling plants of Dwarf Yellow milo and Atlas sorgo, Lawton, Okla., 1935.

and Atlas sorgo, a resistant variety. They were confined in cages that were identical with those used in the oviposition studies. One nymph was placed in each cage, 25 cages being used for each variety. When a first-instar nymph died, it was replaced by a nymph of the same age that had been feeding on the same variety.

The results of this experiment are given in table 2 and shown graphically in fig. 1. In every case the average duration of each stadium was less when the nymph was reared on Dwarf Yellow milo than when fed on Atlas sorgo. In the first generation this difference was small during the first three stadia, but the average duration of the fifth stadium was almost twice as long as for bugs feeding on Atlas as for those feeding on Dwarf Yellow milo. The last nymph reached the adult stage on Dwarf Yellow milo the same day that the first adult appeared on Atlas. The total duration of the nymphal stages was 45 days on Atlas sorgo and only 35 days on Dwarf Yellow milo.

The mortality[1] was relatively high for the first-generation nymphs on both varieties during the first stadium, as may be seen in fig. 2. Twelve nymphs were replaced on Dwarf Yellow milo and 21 were replaced on Atlas sorgo. Of the 25 nymphs that reached the second instar on each variety, only four became adults on Atlas sorgo while 23 reached the adult stage on Dwarf Yellow milo. All four of the bugs that were reared on Atlas sorgo were sluggish and died within three days after becoming adults. The 23 bugs that reached the adult stage on Dwarf Yellow milo were active, many copulated, and all females oviposited. The average body length of the fifth-instar nymphs and the adult bugs reared on Dwarf Yellow milo was about .5 mm. greater than for those reared on Atlas sorgo.

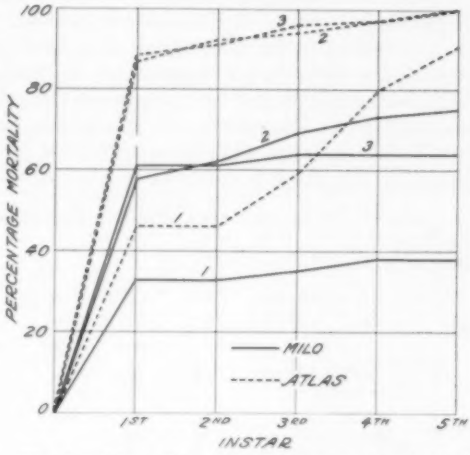

Fig. 2.—Mortality of the first, second and third generation of chinch bug nymphs reared on seedling plants of Dwarf Yellow milo and Atlas sorgo, Lawton, Okla., 1935. (Numbers refer to generations.)

Similar results were obtained with the second and third-generation nymphs. The mortality of the first-instar nymphs, however, was higher in the second and third generations than in the first. During the later stadia of the second generation and all the stadia of the third generation a lower temperature prevailed, which might have caused the average duration of the stadia to be longer. One bug of the second generation feeding on Dwarf Yellow milo reached the adult stage 27 days after hatching, this being the shortest time required for any individual during these experiments. Of the 52 second-generation nymphs that were started on Dwarf Yellow milo, 23 reached the second instar and 13 of this number became adults. Only eight of the 63 nymphs that were started on Atlas sorgo reached the second instar and none reached the adult stage. Two nymphs on Atlas reached the fifth instar, one living eight days and the other 30 days after reaching that stage. As in the first generation, the body length of the second and third-generation nymphs that fed on Dward Yellow milo was greater than that of those feeding on Atlas. The mortality of third-generation nymphs feeding on Atlas sorgo was again 100 per cent. On Dwarf Yellow milo the mortality of the nymphs was greatest in the second generation and lowest in the first. Of the 13 nymphs that reached the second instar on Dwarf Yellow milo 12 became adults. The rate of development of third-generation nymphs was somewhat slower than that of nymphs of the first and second generations.

[1] Figures on mortality are probably rather low, because no data were taken in the cages containing the mass cultures from which replacements were obtained.

Host-preference studies. Laboratory experiments were conducted to study the host preference of the chinch bug. A cage 22 inches long and 6 inches wide, equipped with a sliding-glass top, was constructed for these tests. Ten holes were bored 2 inches apart in the bottom of the cage. One-ounce screw-top medicine bottles were screwed into these holes from the bottom of the cage and filled with water. Seedling plants of the two varieties to be compared were inserted alternately in these holes, so that the roots were submerged in the bottles of water and the upper portions of the plants extended into the cage. Cotton was packed around each plant at the mouth of the bottle to prevent the escape of bugs. Adult chinch bugs were then collected from corn plants in the field and placed in the cage. Counts of the bugs on each plant were made at inter-

Table 3.—Host-preference studies with the chinch bug, Lawton, Okla., 1935.

Experiment No.	Host	Number of Bugs Feeding on Plants							Percentage of Bugs on Each Variety
		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Total	Average per Trial	
1	Dwarf Yellow milo	16	20	11	9	17	73	14.6	80
	Atlas sorgo	7	2	3	5	1	18	3.6	20
2	Feterita	90	73	60			223	74.7	55
	Atlas sorgo	72	68	41			181	60.3	45
3	Blackhull kafir	56	73	102	43		274	68.5	64
	Atlas sorgo	51	42	35	24		152	38.	36
4	Barley (Manchuria)	34	53	63	31	36	217	43.4	71
	Oats (Kanota)	17	10	25	17	21	90	18.	29
5	Wheat (Turkey)	11	32	46	41	12	142	28.4	32
	Barley (Manchuria)	58	68	58	65	54	303	60.6	68

vals of about two hours. After each count the bugs were removed from all plants and distributed evenly in the cage.

The results of these counts are shown in table 3. The bugs showed a decided preference for Dwarf Yellow milo over Atlas sorgo. A distinct preference for Blackhull kafir over Atlas sorgo was noted. The preference for feterita over Atlas sorgo was not so marked. There was a marked preference for barley when compared with either wheat or oats.

Tolerance of different sorghum varieties to chinch bugs.—A study was also made of the tolerance of four varieties of sorghum to uniform infestations of chinch bugs. Single plants of Atlas sorgo, feterita, Blackhull kafir and Dwarf Yellow milo varieties were grown in 6-inch flower pots. When the plants were about 10 inches high and had an average of about six leaves per plant, they were brought into the laboratory and each was covered with a celluloid tube about 8 inches long and 5 inches in diameter, which was open at both ends. One hundred adult chinch bugs were used as the unit infestation for each plant. Four plants of each variety were infested while four others were used as checks.

The results of these experiments are recorded in table 4. In each case the Dwarf Yellow milo plants were the first to die and the Atlas sorgo plants survived the longest. One Dwarf Yellow milo plant was dead after 65 hours, while no Atlas sorgo plant died in less than 113 hours. One

Atlas plant survived more than 121 hours after being infested. The checks remained unchanged in all cases.

Summary.—When female chinch bugs were confined with seedlings of several varieties of sorghum and other host plants, they deposited the most eggs on Dwarf Yellow milo sorghum and the next greatest number on Manchuria barley. Then in order came Blackhull kafir, Hays Golden corn, Kanota oats, Sudan grass, Turkey wheat, Atlas sorgo, and common feterita. Approximately the same number of eggs were deposited in cages with oats and Sudan grass seedlings. No eggs were laid in the cages with feterita plants. The greatest number of eggs were deposited by females confined with tender shoots from Johnson grass plants.

Table 4.—Tolerance of four varieties of sorghum to a uniform infestation of chinch bugs under controlled conditions, Lawton, Okla., 1935.

Variety	Plant No.	Condition of Plants at End of								Av. No. Hours Plants Lived
		17 Hrs.	40 Hrs.	65 Hrs.	72 Hrs.	88 Hrs.	112 Hrs.	121 Hrs.	137 Hrs.	
Atlas sorgo	1	A*	A	A	B	C	C			124.5
	2	A	A	B	B†					
	3	A	A	B		D	F			
	4	A	A	B		C	E	E	F	
Feterita	1	A	A	C	C†					115.
	2	A	A	C	C	D	F			
	3	A	A	C		D	E	F		
	4	A	B	D		E	F			
Blackhull kafir	1	A	A	C	C†					96.
	2	A	A	D	D	F				
	3	A	B	D		F				
	4	A	A	C		E	F			
Dwarf Yellow milo	1		B	D	E	F				78.3
	2		C	E	F					
	3	A	B	E		F				
	4	B	D	F						

* A, no injury; B, basal leaves slightly wilted; C, part of basal leaves permanently wilted; D, about half of the leaves of the plant permanently wilted; E, entire plant nearly dead; F, entire plant dead.

† Discontinued, plant photographed.

There was a marked variation in the longevity of females when confined with these different food plants, and this was not always correlated with the total number of eggs laid. Bugs of both generations lived longest on Johnson grass. Then in order for the first generation came Hays Golden corn, Manchuria barley, Dwarf Yellow milo, Blackhull kafir, Kanota oats, Sudan grass, Turkey wheat, Atlas sorgo and feterita; and for the second generation, Dwarf Yellow milo, Manchuria barley, Hays Golden corn, Blackhull kafir, Sudan grass, Kanota oats, Turkey wheat, feterita and Atlas sorgo. In both generations the last two were practically the same in their influence on longevity.

Chinch bug nymphs reared on Dwarf Yellow milo, a susceptible variety under field conditions, developed more rapidly and were larger and more vigorous than those reared on Atlas sorgo, a resistant variety. Adult chinch bugs under laboratory conditions showed a preference for susceptible varieties over resistant varieties. The resistant variety Atlas sorgo showed greater tolerance to a uniform infestation of adult chinch bugs than any of the other varieties tested.—9-21-36.

PARASITES OF HORN FLY

AND OTHER FLIES BREEDING IN DUNG[1]

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During the studies of parasites and predators of blowflies conducted at Uvalde, Tex., it was frequently observed that many species of dung-inhabiting insects were attracted to carcasses by the contents of the entrails and became closely associated with insects breeding in carrion. Because of this close relationship it was deemed advisable to give some attention to the parasities of diptera breeding in dung. In these investigations two pteromalids, *Spalangia muscidarum stomoxysiae* Gir. and *S. drosophilae* Ashm., were often found in cow dung, and it was indicated that they might be valuable parasites of the horn fly, *Haematobia irritans* L. The following information on these two pupal parasites and their relations to the horn fly and other diptera in cattle droppings has been obtained since 1932.

Pinkus (*1*) made some observations on the life history of *Spalangia muscidarum* Rich. He found the parasite breeding in the pupae of the stable fly, *Stomoxys calcitrans* L., and stated that in nature the stable fly was undoubtedly the principal host of the parasite although it was experimentally reared in *Musca domestica* L., *Haematobia irritans* L., and other dipterous pupae. He did his work in the fall and found the developmental period of the parasite to be from 84 to 106 days.

Richardson (*2*) made a detailed study of the development of *S. muscidarum* in the pupae of the house fly. He carefully described the immature stages and showed that the parasite is hypermetamorphic in development.

Habits and development.—At Uvalde, Tex., it was found that these two pupal parasites were attracted to dry or partly dry cattle droppings. The parasites, when in search of host pupae, follow the tunnels made by dipterous larvae and small species of dung beetles. *Spalangia muscidarum stomoxysiae* does not have a preference for any particular host, but readily attacks pupae of *Cryptolucilia*, *Sarcophaga*, *Haematobia irritans*, and *Musca domestica* in cattle droppings. The parasites have also been reared experimentally from diptera breeding in meat.

Spalangia drosophilae parasitizes the small dung-infesting diptera but will also attack the horn fly. This parasite was found to be hyperparasitic and caused considerable damage to two blowfly parasites, *Alysia ridibunda* Say and *Psilodora rufocincta* K., which were being reared at the laboratory.

The length of the immature stages was determined by placing the parasites together with reared host pupae in glass vials.

Seventeen tests on the developmental period of *S. muscidarum stomoxysiae* were conducted in May, June, July and August 1933. *Haematobia*

[1] The writer is indebted to the following specialists for the determination of the insects: *Sarcophaga*, David G. Hall; *Spalangia*, A. B. Gahan; Staphylinidae, E. A. Chapin; and to D. C. Parman for helpful suggestions in the prosecution of this work.

irritans was used as the host except for two tests with *Cryptolucilia* and one each with *Sarcophaga effreneta* Walk., *Sarcophaga sueta* V. d. W. and *Sarcophaga impar* Ald. The average developmental period was 22.8 days, with a maximum of 35 and a minimum of 17 days. The average daily temperature was 83.1° F. The shortest periods of development, *i.e.*, less than 20 days, occurred during the hottest part of the summer at a daily mean temperature of 86.7° F. The developmental period of the parasite in cattle droppings in the field was shorter than in the laboratory. The developmental period of *S. drosophilae* was found to be approximately the same as that of *S. muscidarum stomoxysiae*.

Both species mate shortly after emergence. Males usually emerge slightly before the females, and in nature mating probably takes place in or close to the material from which the parasites emerge. The females usually examine the puparia for three to 10 minutes before ovipositing. When the desired location is found, the ovipositor is thrust in and the insect remains quiet except for a slight vibration of the ovipositor. Usually five to 10 minutes elapse before the ovipositor is withdrawn. Both species of parasites are solitary, only one adult issuing from each puparium.

The progeny resulting from a reared specimen of *S. muscidarum stomoxysiae* supplied with *Sarcophaga* and *Cryptolucilia* pupae over a 15-day period comprised, in one instance, 70 females and 12 males, and in another, 32 females and 17 males. Of 732 emerged specimens of *S. muscidarum stomoxysiae*, 66 per cent were females. Unfertilized females of both species of *Spalangia* will oviposit, but the resulting progeny are all males.

Table 1.—Longevity of adults of *Spalangia muscidarum stomoxysiae* when given different kinds of food.

Food	Longevity, Days
No food or water	4.
Fly puparia	8.4
Water on sponge	8.8
Honey and water	11.2

The average adult longevity of 109 reared *S. muscidarum stomoxysiae* kept in vials without food or water, in June 1933, was 5.4 days, with a range of one to 13 days. Specimens have been kept alive for 25 days. Four longevity tests in August 1933 gave the results shown in table 1.

Females of *Spalangia drosophilae* have lived 31 days in vials with honey and water, but during the summer the average length of life is about 15 days.

Percentage of parasitization.—In an effort to determine the percentage of parasitization by *Spalangia* and also to discover other parasites, 67 cattle droppings three or four days old, collected in the field, were placed on sand in individual pans and brought to the laboratory. These droppings were kept in the laboratory yard, where a natural infestation by parasites could take place. When the droppings were eight to 10 days old, the sand was sieved and the pupae of the host species segregated in vials. The manure was carefully shredded and examined for pupae, which were put in vials separate from those containing the specimens that had pupated in the sand. Although the droppings were moved from

the field to the laboratory, it is believed that a fair indication is given of the degree of parasitization in nature. Moreover, examinations of droppings in the field gave results similar to those obtained in the foregoing tests.

Table 2 shows the degree of parasitization occurring in the flies reared from the two situations, sand and manure. Of particular interest is the comparatively large percentage of parasitization in the fly larvae that

Table 2.—Parasitization of *Sarcophaga* and *Cryptolucilia* sp. and *Haematobia irritans* bred from 67 cattle droppings, Uvalde, Tex., May 15 to Aug. 7, 1933.

Host Species	Puparia in Sand			Puparia in Manure		
	Total No.	Per Cent Parasitized by *Spalangia*	Per Cent Parasitized by *Baryodma bimaculata*	Total No.	Per Cent Parasitized by *Spalangia*	Per Cent Parasitized by *Baryodma bimaculata*
Sarcophaga sp. and *Cryptolucilia* sp.	2541	14.6	23.9	329	43.8	32.8
Haematobia irritans	55	38.2	0	28	64.3	0

migrated from the manure. *Haematobia*, as well as *Sarcophaga* and *Cryptolucilia*, when migrating into the soil or sand beneath a dropping, leaves a connecting tunnel through which *Spalangia* and other pupal parasites have easy access. *Spalangia* is readily found in the field working underneath and within droppings.

Spalangia accounted for the destruction of 18.7 per cent of the fly pupae, while *Baryodma bimaculata* destroyed 24.2 per cent of the fly pupae. Over 95 per cent of the *Spalangia* emergence was *S. muscidarum stomoxysiae*. Fifty-four per cent of the droppings were infested by *Spalangia*, while in a series of 27 droppings covered by cages in the field 48 per cent yielded *Spalangia*.

Table 3.—Emergence of *Haematobia and *Spalangia* from puparia in 96 artificial patches of cow dung, Uvalde, Tex., 1933.**

Date	No. Patches	Per Cent of Patches Infested by *Spalangia*	Flies and Parasites Emerging in Sand			Flies and Parasites Emerging in Manure			Total Flies and Parasites Emerging	
			Haematobia	*Spalangia* spp.		*Haematobia*	*Spalangia* spp.		*Spalangia* spp.	
			no.	no.	per cent	no.	no.	per cent	no.	per cent
July 4 to Aug. 2	15	66.66	69	55	44.35	55	32	36.78	87	41.23
Aug. 4 to Sept. 22	49	30.61	494	96	16.27	451	63	12.26	159	14.4
Sept. 29 to Dec. 14	32	9.38	196	23	10.5	262	2	.76	25	5.18
Total	*96*	*29.17*	*759*	*174*	*18.6*	*768*	*97*	*11.22*	*271*	*15.0*

* Infestation of dung by *Haematobia* was secured in cages.

The number of staphylinid beetles that emerged from *Sarcophaga* and *Cryptolucilia* pupae was of interest. A few of these beetles were determined as *Baryodma bimaculata* Grav., and all were probably of the same species. The tiny newly hatched larva of this beetle gnaws a minute hole in the fly puparium, through which it enters and consumes the host. The beetle larva goes through a hypermetamorphic development requiring approximately 20 days. No beetles emerged from pupae of *Haematobia*, and in only one instance was a beetle larva found in a *Haematobia* pupa.

Because of the scarcity of horn fly pupae in field droppings, another method was used to determine the percentage of parasitizations by *Spalangia*. Small patches of fresh uncontaminated cow dung on sand in pans were exposed to horn flies in a cage. These patches were approximately 5 inches in diameter and 1½ inches in depth, much smaller than the usual field droppings. From one to three days after oviposition by *Haematobia*, the dung patches were exposed to natural parasitization in the laboratory yard and treated similarly to the field droppings. A total of 96 tests were made from July 4 to December 14, 1933, and the emergence of flies and parasites is presented in table 3.

The parasitization by *Spalangia* of the horn flies that migrated to the sand was 18.65 per cent and in the manure 11.22 per cent, making an average of 15.07 per cent. Over 95 per cent of the *Spalangia* were *S. muscidarum stomoxysiae*. It was observed that the period of greatest activity of *Spalangia* was in July, and a decrease of parasitization continued through the fall.

In a series of dung patches exposed to *Spalangia* in cages during June 1933 an average parasitization of 55.19 per cent occurred. This merely represented what occurred under laboratory conditions, but it indicates *Spalangia* is capable of destroying considerable numbers of horn flies.

Summary.—*Spalangia muscidarum stomoxysiae* Gir. and *S. drosophilae* Ashm. were found to be attracted to dry or partly dry cattle droppings at Uvalde, Tex. *S. muscidarum stomoxysiae* attacks pupae of *Sarcophaga*, *Cryptolucilia*, *Haematobia irritans* L., and *Musca domestica* L. in and under cattle droppings. *S. drosophilae* parasitizes small dipterous pupae but will also attack *H. irritans*.

The average developmental period of *S. muscidarum stomoxysiae* was 22.8 days during the spring and summer, with a daily mean temperature of 83.1° F. Adult longevity was as much as 25 days with *S. muscidarum stomoxysiae* and 31 days with *S. drosophilae*.

The percentage of parasitization by *Spalangia* was determined by collecting and segregating the dipterous pupae in and under cattle droppings. In 67 field droppings 14.6 per cent of the *Sarcophaga* and *Cryptolucilia* that migrated and 43.8 per cent of those that remained in the manure were parasitized by *Spalangia*. With the *Haematobia* 38.2 per cent of those that migrated and 64.3 per cent of those in the manure were parasitized. Over 95 per cent of the *Spalangia* were *S. muscidarum stomoxysiae*. A staphylinid beetle, *Baryodma bimaculata* Grav., accounted for a parasitization of 24.9 per cent of the *Sarcophaga* and *Cryptolucilia*.

In a series of 96 artificial patches of cow dung infested with *H. irritans* a total parasitization of 15.1 per cent by *Spalangia* occurred.

S. muscidarum stomoxysiae offers possibilities as a means of biological control of the horn fly. The habits of the insect are such that artificial propagation appears favorable.—1-17-36.

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HANDY INSECT CAGES MADE FROM CELLOPHANE[1]

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Satisfactory cages for containing, moving and observing small insects and other small phytophagous arthropods may be constructed readily from plain Cellophane (not moisture proofed) and other similar films. An envelope of the shape shown in fig. 1 is first cut from a sheet of the film. The size of the envelope is determined by the size of the plant or part of plant which it is desired to enclose with the insects. As a general practice it is well to make the envelope about an inch larger in each dimension than the actual measurements of the material to be enclosed.

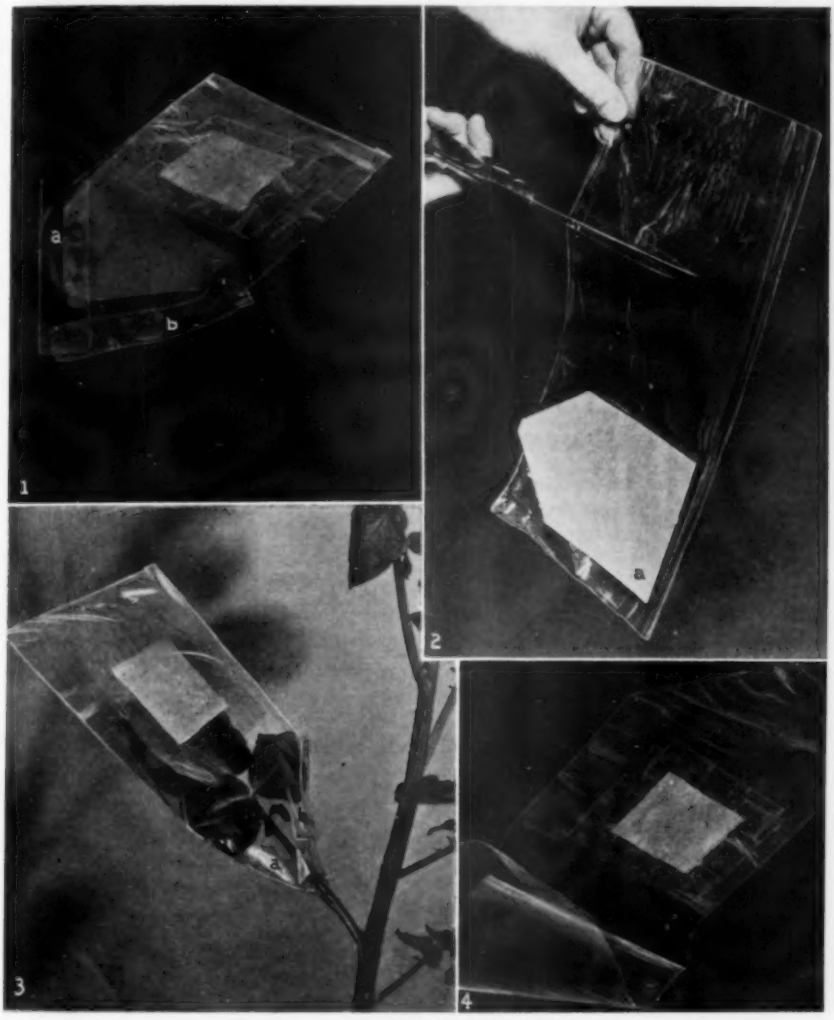
An easy method of constructing envelopes is to fold a sheet of Cellophane as indicated in fig. 2 and then cut the material into the desired widths. When many cages of the same size are needed, they may be cut out more quickly and easily by first cutting a templet of metal on heavy cardboard as shown in fig. 2a. Place the templet on the fold as shown and cut around the sides and end with a razor blade or similarly sharp instrument. The sides of the envelope are then closed by means of adhesive tape. Scotch cellulose tape three-quarters of an inch wide may be used for the purpose. Two additional strips of the tape are laid along the open end of the envelope as shown in fig. 1, a and b. When the envelope is to be attached to a plant, the insects are first placed at the bottom of the envelope and the plant inserted into the open end. The two strips of tape are then folded over so as to close the open end of the envelope and fasten the envelope to the plant as shown in fig. 3, a and b. Usually this method of securing the envelope to the plant is quite satisfactory. The ends of the two strips of tape fold about the stem or petiole of the plant, thereby sealing the envelope. To permit expansion of the stem or petiole or to avoid the occasional loss of insects through their becoming enmeshed in the adhesive, it is sometimes desirable to wrap a thin compact band of absorbent cotton or felt about the stem or petiole and fold the strips of tape over the cotton or felt and upon the stem or petiole.

It is necessary to use moisture-permeable material in the construction of these envelopes. Otherwise, since moisture frequently condenses upon the inside of the envelopes if moisture-proof material is used, small insects may be lost by drowning.

Ventilation is also necessary in the envelopes. Even though moisture-permeable material is used, toxic gases accumulate in the envelope and destroy the enclosed plants. For this reason a "window" of silk or other fine-mesh fabric is placed in one side of the envelope. A piece of silk about

[1] This paper is published with the approval of the Director of the Wisconsin Agricultural Experiment Station.

an inch square usually is sufficient. The piece of fabric may be fixed over the opening in the side of the envelope by means of the tape and is best inserted before the envelope is closed as shown in fig. 4.



Figs. 1–4.—Details of construction and use of insect cages made from Cellophane.

There are several advantages in the use of a cage made of this material. It is easily and quickly constructed without the use of special apparatus. The caged insects may be viewed readily through the cage and observed as frequently as desired without disturbing the insects or the cage. In

life-history or insect-transmission of plant-pathogene studies, the insects may be moved from plant to plant without being lost. When it is desired to move the envelope and the enclosed insects to a new plant it is necessary only to shake or jar the insects to the bottom of the envelope, open the opposite end by cutting through the two strips of tape, fig. 3, a and b, remove the envelope, and slip it over a new plant. Seal as before with new strips of tape.

When it is desired to place the envelope over an entire plant the envelope may be fixed in position on the plant first and the insects introduced through a hole in the envelope which may be closed later by means of the tape. The tape is very adhesive and every effort must be made to prevent the enclosed insects from becoming enmeshed in the adhesive and destroyed.—10-7-36.

TOXICITY OF CERTAIN STOMACH POISONS TO SEVERAL COMMON LEPIDOPTEROUS LARVAE[1]

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Larvae of the order Lepidoptera comprise a large percentage of the total number of injurious species of insects. Metcalf & Flint (7) list some 58 species of Lepidoptera as important pests of field, vegetable, or tree-fruit crops. Affecting the same groups are listed 56 species of Coleoptera and some 65 species from all other orders. Since the control of these various caterpillars is largely accomplished by applications of stomach poisons as sprays, dusts or poison baits, it may be logically assumed that the evaluation of the toxicity of these poisons is one of the more important problems of applied entomology. In this paper the authors propose to bring together all experimentally determined median lethal doses (M.L.Ds.) of poisons for lepidopterous larvae that have come to their notice. To this will be added 23 further determinations made by themselves. Such a compilation of data should facilitate certain interesting and valuable comparisons. The fact that the authors limit the subject matter of this paper to Lepidoptera should not be construed as an indication of the unimportance of similar work dealing with other insects, for stomach poisons are of nearly equal importance in the subjugation of these groups. Nor should the apparent disregard of the excellent comparative toxicity work done in Germany and elsewhere with Lepidoptera, in which cage or feeding technics were used but the actual M.L.D. not determined, be interpreted as derogatory to either their results or their methods. The experimental determination of an M.L.D., however, not only gives the most accurate estimate of the toxicity of a stomach poison when used against a certain insect, but also serves as a valuable standard for comparative field tests.

Materials.—The larvae used in these experiments were largely those

[1] Journal paper J-352 of the Iowa Agricultural Experiment Station. Project 389.

which were available in the field during the growing seasons of 1933, 1934 and 1935. With the exception of the silkworms, *Bombyx mori* L., and two generations of corn ear worms, *Heliothis obsoleta* Fab., raised in the greenhouse in the fall of 1934 by the method described by Ellisor (*4*), all the larvae were gathered in the field immediately prior to the test. Other insects used were the imported cabbage worm, *Ascia rapae* L., the yellow-necked caterpillar, *Datana ministra* Drury, *Datana perspicua* G. & R., the armyworm, *Cirphis unipuncta* Haw., the semicolon, *Polygonia interrogationis* Fab., and the painted lady, *Vanessa cardui* L.

The sources and composition of the various poisons tested were:

Acid Lead Arsenate.—A proprietary sample analyzed in 1930 and found to contain 64.50 per cent PbO, 32.88 per cent As_2O_5, and .22 per cent water-soluble As_2O_5.

Calcium Arsenate.—Sample A was a proprietary sample (*Niagara Brand*) analyzed in 1930 and found to contain 33.16 per cent CaO, 31.23 per cent As_2O_5, and .29 per cent water-soluble As_2O_5. Sample B was another (*Chipman Brand*) packed in 1934, opened in August 1935, and used immediately.

Manganese Arsenate.—From a freshly opened proprietary package (*Manganar*, made by the Grasselli Chemical Co.).

Paris Green.—A proprietary sample analyzed in 1930 and found to contain 38.84 per cent CuO, 54.75 per cent As_2O_3, and 3.00 per cent water-soluble As_2O_3.

Zinc Arsenite.—From a freshly opened sack of *Acme Brand Zinc-arnite;* 90 per cent zinc arsenite, not less than 30.5 per cent metallic arsenic, not more than 1 per cent soluble metallic arsenic.

Zinc Phosphide Merck.—Analyzed in 1930 and found to contain 98.7 per cent Zn_3P_2.

Phenothiazine.[2] Pure.

Diphenylene Oxide.[2] *Eastman Technical.*

Dihydrorotenone.[2] Pure, m.p. 200–202° C.

Rotenone.—Chemically pure, m.p. 163° C.

Methods.—Certain modifications were made of the Campbell & Filmer (*3*) and Stellwaag (*10*) sandwich method of feeding measurable doses of poisons to leaf-feeding insects. Leaf discs of known area were dusted by the air-float method under a large bell jar. With the discs was a rectangular paper of exactly 10 times the area of a single leaf disc. Weighings of this paper made before and after the deposition of poison gave a close estimate of the amount of poison on each disc.

Most larvae were observed to feed on a single leaf disc without disturbing the dusted surface when it was placed on moist sand in a stender dish with the dusted surface facing downward. For insects as large as fifth-instar silkworms, or when dry smooth leaves such as those of the mulberry were used, this method was least satisfactory. However, Campbell's median lethal dose (M.L.D.) of .09 milligram per gram of acid lead arsenate for fourth-instar silkworms was twice duplicated in this laboratory by independent workers, as well as his dose of .003 milligram per

[2] The authors wish to express their thanks to Dr. R. C. Roark, in charge of the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine, for furnishing these samples.

gram of rotenone for the same larva. In order to feed toxic doses of relatively nontoxic compounds such as diphenylene oxide, the paste sandwich method was used. The single-leaf method was found most applicable when using insects of medium size and compounds whose M.L.D. was .3 milligram per gram or less. When the sandwiches were made of waxy rape leaves, or the rough-surfaced leaves of elm, thistle or

Table 1.—Median lethal doses of stomach poisons in milligrams per gram of body weight tested against lepidopterous larvae.

Insect	*Ascia rapae*	Fourth Instar *Bombyx mori*	Fifth Instar *Bombyx mori*	*Heliothis obsoleta*	*Cirphis unipuncta*	*Datana ministra*	*Datana perspicua*	*Polygonia interrogationis*	*Vanessa cardui*
Acid lead arsenate	60* .09–.10 .09	77 .057–.121 .09	55 .074–.133 .09	62 .11–.29 .17	53 .20–.34 .25	48 .02–.10 .05	51 .05–.10 .07	81 .036–.071 .06	74 .14–.19 .16
Calcium arsenate, sample A	56 — >1.39	47 — >.78							
Calcium arsenate, sample B		68 .123–.332 .26							
Manganese arsenate						40 .10–.25 .15			
Zinc arsenite	54 — >1.99								
Paris green	77 .02–.06 .04								
Zinc phosphide	40 — >3.50			26 — >.87			39 .23–.60 .47		
Diphenylene oxide							37 .53–1.48 .96		
Phenothiazine	32 — >1.12								
Rotenone				87 — >.49					85 .021–.072 .03
Dihydrorotenone						46 .07–.18 .11			

* The first figure in the data for each insect is the number of insects upon which the M.L.D. is based; the second, the range of doses in the intermediate zone—that is, those doses between the lowest lethal and highest nonlethal dose. The third or lower figure is the M.L.D.

wild crab, the modified method gave excellent results. The occasional insect which disturbed the coverage of poison by crawling over the disc was discarded. Particularly if the insects were starved for a few hours or over night, they began feeding immediately upon being placed in the stender dish.

The areas eaten by the larvae were calculated by counting, under a binocular microscope, the number of square millimeters which were exposed when the partly eaten leaf disc was superimposed on a circle of

the same size marked on millimeter cross-section paper. Independent observations by several workers established the maximum error of about 3 per cent for this method of measuring area. Although the rapidity with which measurements may be made is in itself useful, the elimination of practically all shrinkage of succulent leaves by measuring and discarding

Table 2. Part I.—Median lethal doses of certain stomach poisons in milligrams per gram of body weight tested against lepidopterous larvae; compiled from the literature.

Insect	Poison	M.L.D.	Source
Bombyx mori L.*	$PbHAsO_4$	.09	Campbell (*3*)
Bombyx mori L.	$PbHAsO_4$	.09	Shepard (*8*)
Bombyx mori L.	$PbHAsO_4$	.086	Bulger (*1*)
Bombyx mori L.	Rotenone	.003	Shepard (*8*)
Bombyx mori L.	Rotenone	.003	Kagy (*5*)
Bombyx mori L.	Dihydrorotenone	$<.01$	Shepard (*8*)
Bombyx mori L.	Deguelin	.010–.012	Shepard (*8*)
Bombyx mori L.	Tephrosin	.03 –.06	Shepard (*8*)
Bombyx mori L.	Toxicarol	>1.54	Shepard (*8*)
Bombyx mori L.	Derritol	$>.87$	Shepard (*8*)
Bombyx mori L.	Rotenol	$>.51$	Shepard (*8*)
Bombyx mori L.	Dehydrorotenone	$>.40$	Shepard (*8*)
Bombyx mori L.	Tubaic acid	$>.54$	Shepard (*8*)
Bombyx mori L.	Malachite green	.025	Campbell (*2*)
Bombyx mori L.	Safranin bluish	.025–.05	Campbell (*2*)
Bombyx mori L.	Brilliant green	.05	Campbell (*2*)
Bombyx mori L.	Crystal violet	.05 –.10	Campbell (*2*)
Bombyx mori L.	As_2O_3	.015–.02	Campbell (*2*)
Bombyx mori L.	As_2O_5	.030–.040	Campbell (*2*)
Bombyx mori L.	NaF	.11 –.15	Shepard (*9*)
Bombyx mori L.	MnF_2	.30 –.40	Shepard (*9*)
Bombyx mori L.	PbF_2	.25 –.40	Shepard (*9*)
Bombyx mori L.	MgF_2	$>.57$	Shepard (*9*)
Bombyx mori L.	Na_2SiF_6	.10 –.13	Shepard (*9*)
Bombyx mori L.	Na_2SiF_6	.09	Campbell (*3*)
Bombyx mori L.	K_2SiF_6	.07 –.10	Shepard (*9*)
Bombyx mori L.	K_2SiF_6	.13	Campbell (*3*)
Bombyx mori L.	$BaSiF_6$	.09 –.12	Shepard (*9*)
Bombyx mori L.	$BaSiF_6$	.17	Campbell (*3*)
Bombyx mori L.	Na_3AlF_6	.05 –.07	Shepard (*9*)
Bombyx mori L.	Na_3AlF_6	.18	Campbell (*3*)
Bombyx mori L.	K_3AlF_6	.08 –.10	Shepard (*9*)
Bombyx mori L.	$(NH_4)_3AlF_6$	.11 –.14	Shepard (*9*)
Bombyx mori L.	Basic lead arsenate	.9	Campbell (*3*)
Bombyx mori L.	Aluminum arsenate	.9	Campbell (*3*)
Bombyx mori L.	$PbHAsO_4$ (with $Ca(OH)_2$)	.074	Bulger (*1*)
Bombyx mori L.	$PbHAsO_4$ (with calcium caseinate)	.062	Bulger (*1*)

* All *Bombyx mori* are fourth instar.

the discs within one or two minutes after the larvae have ceased feeding is considered to be of greater importance.

When a new compound is to be tried, and one has no previous estimate of its toxicity, it is important that the results of the introductory test be made immediately available to serve as a guide for later careful dosage. With the above method one worker may, for many insects and poisons, determine with accuracy an M.L.D. based on 60 to 100 insects in two half-days. About 40 larvae are fed one afternoon with doses rang-

ing from zero to the maximum amount possible. By noon of the next day a fairly accurate estimate of the required dosage has been obtained, and an equal number of larvae are fed doses falling as nearly as possible in the intermediate zone. With practice it is possible to regulate the

Table 2. Part II.—Median lethal doses of certain stomach poisons in milligrams per gram of body weight tested against lepidopterous larvae; compiled from the literature.

Insect	Poison	M.L.D.	Source
Bombyx mori L.*	$PbHAsO_4$ (with $Fe(OH)_3$)	.093	Bulger (*1*)
Bombyx mori L.	CuCN	.037	Bulger (*1*)
Bombyx mori L.	2-4-dinitro-6-cyclohexyl-phenol	.016	Kagy (*5*)
Bombyx mori L.	Calcium 2-4-dinitro-6-cyclo-hexylphenate	.02	Kagy (*5*)
Vanessa cardui L.	2-4-dinitro-6-cyclohexyl-phenol	.02	Kagy (*5*)
Vanessa cardui L.	Calcium 2-4-dinitro-6-cyclo-hexylphenate	.021	Kagy (*5*)
Heliothis obsoleta Fab.	2-4-dinitro-6-cyclohexyl-phenol	.087	Kagy (*6*)
Heliothis obsoleta Fab.	Calcium 2-4-dinitro-6-cyclo-hexylphenate	.059	Kagy (*6*)
Heliothis obsoleta Fab.	Magnesium 2-4-dinitro-6-cyclohexylphenate	.077	Kagy (*6*)
Heliothis obsoleta Fab.	Lead 2-4-dinitro-6-cyclo-hexylphenate	.084	Kagy (*6*)
Heliothis obsoleta Fab.	Copper 2-4-dinitro-6-cyclo-hexylphenate	.097	Kagy (*6*)
Heliothis obsoleta Fab.	Calcium 2-6-dinitro-4-cyclo-hexylphenate	> .50	Kagy (*6*)
Heliothis obsoleta Fab.	Lead 3-5-dinitro-o-cresylate	> .13	Kagy (*6*)
Heliothis obsoleta Fab.	$PbHAsO_4$	.26†	Kagy (*6*)
Cirphis unipuncta Haw.	$PbHAsO_4$	.25	Kagy (*6*)
Cirphis unipuncta Haw.	Calcium 2-4-dinitro-6-cyclo-hexylphenate	.015	Kagy (*6*)
Ascia rapae L.	$PbHAsO_4$	.09	Kagy (*6*)
Ascia rapae L.	Calcium 2-4-dinitro-6-cyclo-hexylphenate	.073	Kagy (*6*)
Ceratomia catalpae Boisd.	$PbHAsO_4$	.062	Bulger (*1*)
Ceratomia catalpae Boisd.	CuCN	.025	Bulger (*1*)
Malacosoma americana Fab.	$PbHAsO_4$	.15–.21?	Bulger (*1*)
Hyphantria cunea Drury	$PbHAsO_4$	> .16?	Bulger (*1*)
Datana integerrima G. & R.	$PbHAsO_4$	< .05?	Bulger (*1*)

* All *Bombyx mori* are fourth instar.

† The fact that these larvae were collected in the field in July whereas the authors' were reared in the greenhouse in November may account for the disparity between this and the authors' M.L.D. of .17 mg./g.

dosage with considerable accuracy by controlling the amount of dust deposited on the discs and the length of time the larva feeds.

Results.—The results in table 1 are largely self-explanatory. Those doses marked "greater than a certain amount" indicate that doses ranging up to the amount mentioned did not kill any of the larvae. Checks which accompanied all experiments indicated that only about 2 per cent of healthy larvae die in less than 96 hours, the time during which the

larvae were observed after administration of the poison. Parasitized larvae were eliminated as soon as they were noticed.

Discussion.—Since the number of median lethal doses that have been determined for various compounds tested against lepidopterous larvae by other workers is not large, a list of those which have come to the attention of the authors is presented here, table 2, in the belief that certain interesting comparisons might be made.

Comparisons may now be made between the M.L.Ds. of different compounds used against the same species and between the toxicity of the same compounds to different species. Due to the paucity of determinations made on other species, most of the comparisons of poisons must be made among data from the silkworm. Upon examination of the first part of table 2 it will be observed that the M.L.Ds. for various related groups of compounds may themselves be grouped. The derris derivatives fall into two groups. The first, comprising rotenone, dihydrorotenone, deguelin and tephrosin, is the most toxic class of compounds tested against the silkworm, whereas tubaic acid, dehydrorotenone, and the alcohols, toxicarol, derritol and rotenol are relatively nontoxic. Next in toxicity to the derris derivatives is 2-4-dinitro-6-cyclohexylphenol and its calcium salt. With M.L.Ds. of .015 to .040 milligram per gram of body weight, the arsenious and arsenic anhydrides are next in order of toxicity. The four dyes reported by Campbell (*2*) may be classed in the following group, with M.L.Ds. ranging from .025 to .10 milligram. Along with lead arsenate, whose M.L.D. is .09 milligram, fall the fluosilicates and fluoaluminates, with M.L.Ds. from .05 to .18 milligram. The fluorides are toxic in the order of their solubility, their M.L.Ds. ranging upward from .11 milligram per gram. Aluminum arsenate and basic lead arsenate are the least toxic of any compounds whose actual M.L.Ds. have been determined.

The M.L.D. for acid lead arsenate has been determined for 12 species. The figures range from less than .05 milligram to .26 milligram. Of some interest is the fact that the two largest doses are for the noctuid larvae *Heliothis obsoleta* and *Cirphis unipuncta*. The three species of *Datana* are killed with practically the same dose, whereas the closely related *Polygonia interrogationis* and *Vanessa cardui* require doses of .06 and .16 milligram per gram respectively.

The median lethal dose of zinc phosphide is .47 milligram per gram for *Datana perspicua*, but .87 milligram per gram is nonlethal to the larvae of *Heliothis obsoleta*, and *Ascia rapae* is not killed with doses as large as 3.5 milligrams per gram.

An outstanding disparity is seen in the apparent lack of toxicity of rotenone for *Heliothis obsoleta*, doses 16 times as large as the M.L.D. for *Vanessa cardui* and 160 times as large as the M.L.D. for *Bombyx mori* being nonlethal to this insect.

According to Kagy's (*6*) data, acid lead arsenate is about one-third as toxic to *Cirphis unipuncta* and *Heliothis obsoleta* as to *Ascia rapae*, whereas calcium 2-4-dinitro-6-cyclohexylphenate is five times and about one and one-fourth times as toxic to the respective species of the noctuids as to the imported cabbage worm.

Several such comparisons might be made from the above compilation of data, but those noted should be sufficient to indicate the specificity of some poisons for the larvae of various closely related insects. The inadequacy of tests employing but one or two species of insects as a criterion of the efficiency of an insecticide is emphasized by these comparisons.

Summary.—A modification of Campbell's method of feeding measurable doses of poison to leaf-feeding insects is described. The authors report 23 determinations for lepidopterous larvae and compile 60 more from the literature. From these data comparisons of toxicity of a poison for different insects and different poisons for the same insect are made. For larvae of the silkworm, *Bombyx mori* L., several organic toxicants including rotenone and some of its derivatives, nitro-phenols, and certain of the coal-tar dyes are most toxic. Following these are lead arsenate and many of the common fluorine insecticides. In the least toxic group are various arsenicals and organic and inorganic compounds. Lead arsenate used against various larvae gives M.L.Ds. ranging from about .05 milligram per gram of body weight for three species of *Datana* to .25 and .26 milligram for the noctuids *Heliothis obsoleta* Fab. and *Cirphis unipuncta* Haw. The observations and comparisons made indicate a rather specific action of many poisons for various lepidopterous larvae.—9-16-36.

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A vetch weevil quarantine prohibiting the shipment of vetch seed into Oklahoma from infested states, effective November 4, was announced by W. J. Lackey, acting quarantine officer for the Oklahoma State Board of Agriculture. These states include New Jersey, Delaware, Maryland, North Carolina, South Carolina, Virginia, Pennsylvania, Rhode Island, Georgia and the District of Columbia. Vetch seed from other states is also regulated requiring special certification and in states east of the Mississippi river the shipments are restricted to certain months of the year.

RELATION OF VISCOSITY TO DROP SIZE AND THE APPLICATION OF OILS BY ATOMIZATION[1]

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Studies conducted at the University of Wisconsin under the John Powell Company fellowship for the study of cattle sprays indicated that it was not possible to apply efficiently commercial cattle sprays of all viscosities with the same atomizer. It was noted that, with the atomizer used in this study, oils of low viscosities were applied quickly and easily, and covered the coats of the animals effectively. A longer time was required to apply a given amount of more viscous oils and the spray produced was less effective in as much as it drifted about and beyond the animals without wetting them.

Cattle-fly sprays to be effective must cover the animals with some material which will protect them from the attack of flies. At the same time it is necessary to avoid injuring the animals by the application of too much oil, which would penetrate the coat and "burn" the animal's hide. Because of the latter condition it is necessary to avoid the application of too much material which quickly wets the animal's coat. With the atomizer used in this study, however, it was not possible to wet the animals in a practical length of time with some of the more viscous sprays because of the finely divided condition of the spray which was carried away from rather than being deposited upon the animals by the air currents produced by the atomizer.

Although the present study is not intended to deal with the comparative effectiveness of oils of different viscosities as vehicles for insecticides used for this purpose, it should be noted that oils of the kerosene type are quickly volatile and do not retain the insecticides in an active condition on the coats of the animals for a sufficient length of time to be practical. Oils of the kerosene type make satisfactory vehicles for insecticides which are used to destroy insects upon which they are sprayed but these oils volatilize quickly and the sprays soon become ineffective when not applied directly to the insects.

Less volatile oils are necessary to maintain the insecticides in an active condition during the period of the day when the flies are active. For this reason, sprays designed to protect the cattle in the field as well as in the barn contain oils of low volatility and high viscosity. These oils present a special problem when used with atomizers of the fixed-nozzle, suction type.

The present study was instituted to investigate the relationship between viscosity and drop size, when a common fixed nozzle, suction-type atomizer was used.

Materials and procedure.—The atomizer used in this test was a commercially manufactured, electrically driven hand unit with a fixed nozzle designed for oils of low viscosity. The oil was drawn to the nozzele by suction only.

[1] Early publication of this paper has been secured by payment of the printing charge. Published with the permission of the Director of the Wisconsin Agricultural Experiment Station.

Two highly refined oils, one a kerosene type and the other a highly viscous oil, were used both undiluted and blended. The blends were made starting with 90 per cent of the kerozene type and 10 per cent of the other and decreasing 10 per cent of the former and increasing 10 per cent of the latter in each mixture until nine blends were made. Nine commercial cattle sprays, designated by letters in table 1, were used and are arranged according to their viscosity, beginning with the least viscous.

Table 1.—Effect of viscosity on time required for application, size and number of drops produced, comparative coverage, and presenting the value $\frac{S \times N}{T}$ as a measure of the effectiveness of a given atomizer with an oil of a given viscosity. Madison, Wis., 1936.

Sprays Tested	Mean Viscosity, Saybolt 100° F	*T* Seconds Required to Spray 25 Cc.	*S* Mean Size Drops. Sq. mm.	*N* Mean No. Drops per .1 Sq. mm.	S×N Sq. mm.	$\frac{S \times N}{T}$
Kerosene	33.2	9.9	.039	47.42	1.851	.1871
90–10*	34.6	11.	.0391	48.05	1.88	.1709
80–20	35.2	11.8	.0335	43.44	1.458	.1236
70–30	38.8	13.	.0206	37.81	.78	.06
60–40	40.1	15.	.0147	36.8	.542	.0316
50–50	42.2	17.6	.011	28.82	3.19	.0181
40–60	46.6	20.6	.011	21.99	.243	.0118
30–70	52.4	26.4	.0107	20.	.214	.0081
20–80	63.	36.4	.0103	12.96	.134	.0037
10–90	76.	54.3	.0067	6.38	.043	.0007
Heavy oil	111.5	88.	.0052	2.89	.015	.0002
Commercial A	34.2	11.6	.029	34.46	1.003	.0865
Commercial B	34.4	11.8	.0249	29.84	.744	.0631
Commercial C	38.6	12.2	.0149	32.78	.49	.0401
Commercial D	42.4	14.2	.0102	21.16	.216	.0152
Commercial E	48.1	18.2	.006	17.6	.106	.0058
Commercial F	50.8	19.7	.0073	15.47	.113	.0057
Commercial G	55.5	23.5	.0067	14.45	.098	.0042
Commercial H	68.9	33.7	.0062	4.99	.031	.0009
Commercial I	79.9	42.3	.0056	6.56	.037	.0008

* In this column the figures at the left show the per cent of kerosene and those at the right the per cent of heavy oil in the mixture.

The viscosity of all materials was determined according to the Saybolt method. The figure given in the table is the mean of the four determinations made for each material.

The effect of voscosity on the time required to atomize a given amount of oil was determined by measuring the time required to atomize 25 cc. of each material tested. The results are given in the table under T and present the mean of three tests made with each material.

To test the effectiveness of the unit in atomizing oils of various viscosities a modification of the method used by French (*1*) was adapted to the purpose. Uniformly lampblacked microscope slides fixed in the center of a 10 by 13-inch backboard were exposed for one second at a distance of 48 inches from the nozzle. Four slides were exposed at each of the two tests made of each material.

Droplets striking the lampblack-covered slides left a record of their comparative diameters in the lampblack.

The diameter of 50 drops, selected at random from each of the eight slides used in each test, was measured by means of an ocular micrometer and dark-field illumination. The mean of the diameters thus measured was determined and used to calculate the mean area of the imprint of the drops. These data are presented under S in the table. The number of drops falling within 10 areas, selected at random, of .1 sq. mm. each were counted on each slide. These areas were delineated by a rectangular aperture in a paper disc placed in the ocular of the microscope and calibrated by means of a stage micrometer. The mean number of drops per .1 sq. mm. was calculated and is presented in the table under N. The comparative area covered by the drops from each spray was calculated by multiplying the mean size of the drops by the mean number of drops per .1 sq. mm. and is presented in a column $S \times N$.

The value $S \times N$ presents data for an accurate comparison of the effectiveness of the atomizer in covering the object sprayed with oils of different viscosities but it does not indicate that the effectiveness of the atomizer is further influenced by the time required to atomize equal amounts of oils of different viscosities. The value $S \times N$ could be made equal for oils of all the viscosities studied if sufficient oil and time were permitted for application. The value $\frac{S \times N}{T}$ is therefore introduced to present the effectiveness of the atomizer in applying oils of different viscosities on a more comparable basis.

Discussion of results.—As the amount of kerosene in the blended oils was decreased and the amount of heavier oil increased, the blend became more viscous and the time required to atomize 25 cc. of the blend increased as shown in the table. In general, the mean size of the droplets produced decreased markedly as the viscosity of the oils increased. These data do not present all of the available information, however. In measuring the droplets, it was found that very few droplets of less than 34 microns in diameter were recorded on the slides and that no droplets of less than 17 microns in diameter were recorded. When this fact is combined with the data presented in column N, it is apparent that as the viscosity of the oil increased, it was nebulized into smaller drops and that fewer droplets struck the slides. The mean size of the drops recorded by the most viscous oil was considerably smaller than that of the kerosene. It is quite obvious that, in addition, a much larger part of the spray produced from the more viscous oils drifted around and past the slides and was completely ineffectual in wetting them since so few droplets were recorded. The less viscous oils were dispersed into droplets of larger average size and in addition into fewer droplets of less than 34 microns in diameter. For this reason the latter oils were more effective in wetting the slides, when applied by the atomizer in question.

The data in the column $\frac{S \times N}{T}$ shows that, with the atomizer used, low viscosity oils were applied much more effectively than those with the highest viscosity and that the value $\frac{S \times N}{T}$ gives an index of the effectiveness of the sprayer in applying the oils of various viscosities.

These data also indicate a probable reason for the failure of sprays containing oils of high viscosity to perform satisfactorily in Peet-Grady and similar testing chambers. The atomizers used to apply the sprays in most of these testing chambers are of the fixed-nozzle, suction type. These produce sprays of satisfactory physical condition when oils within the limits of the range of the atomizer are used but when more viscous oils are used the droplets produced are so small that it is probable that the insects used in the test chamber do not come in contact with a letal amount of the insecticide bearing the spray.

Conclusions.—These data demonstrate that the atomizer used in these tests was quite ineffective in applying oils throughout a wide range of viscosities. It is apparent that the nozzle of the machine was designed for the application of oils of low viscosities and quite incapable of self-adjustment to oils of higher viscosities. It is also indicated that if a cattle spray is to be applied effectively, an atomizer must be used which is either adjusted to the particular viscosity of the spray in question or is capable of effectively applying oils of a wide range of viscosities. These data, combined with observations made during the study indicate that an atomizer must produce a spray having an $\frac{S \times N}{T}$ value of at least .03, to be effective.—10-12-36.

Literature Cited

(*1*) **French, O. C.** 1934. A study of machinery for applying oil sprays. Ag. Eng. Sept.

EFFECT OF GROUND DERRIS UPON PEA APHID[1]

WHEN INFESTING PEAS SUBSEQUENT TO SPRAYING

Theo E. Bronson, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Field tests of ground derris with spreaders and wetting agents used as a spray against the pea aphid, *Illinoia pisi* Kalt., during the 1935 season at Madison, Wis., resulted in excellent control of the pea aphid and apparent temporary protection of the pea plants from subsequent infestation, as reported in a previous paper (*1*).

After thorough application of a spray to plants infested with the pea aphid, a large percentage of the aphids present were killed within 24 hours, and the remainder of the aphids continued to die over a period ranging from three to five days, until in many of the tests a total of 95 percent were killed. During this period the rate of aphid reproduction was much lower than on untreated plants. Upon two other occasions peas sprayed before they were infested or when they were lightly infested were protected from appreciable infestation for two or more weeks.

These observations suggested at least three possibilities of the action of derris when applied as a spray: (1) That a minute quantity of the spray was reaching the aphids and thus eventually killing them, (2) that

[1] Early publication of this paper has been secured by payment of the printing charge.

in some manner the toxic principles of derris were being transmitted to the aphids as they came in contact with the derris coating on the leaf, or (3) that rotenone or other toxic principles contained in the derris were being absorbed into the plant tissue and taken up by the aphids in feeding.

In an effort to determine whether derris sprays have a protective effect on pea foliage, a series of greenhouse tests were conducted during the winter of 1935 in which pea plants were sprayed and later infested with aphids.

The spray consisted of ground derris root containing 3.2 per cent of rotenone and 13 per cent of total extractives, used at a dilution to obtain .0115 per cent of rotenone (3 pounds per 100 gallons of water), and one of two spreaders and wetting agents, a sulfated butylated diphenol at the dilution of 1:600 of a 40 per cent aqueous solution, and a sodium oleyl sulfate, special, at the dilution of 1:1000.

As checks, some potted pea plants were sprayed with nicotine sulfate in water at the dilution of 1:800, with a sulfated butylated diphenol at the dilution of 1:600 of a 40 per cent aqueous solution as a spreader and wetting agent. These plants were infested after the spray had dried. Similar checks were maintained with untreated infested plants.

The technic employed was as follows: Small, uninfested potted pea plants were sprayed thoroughly, allowed to dry for 24 hours and then lightly infested with third and fourth-stage pea aphid nymphs and properly caged. There was an average of four plants to the pot.

Twenty-four pots of peas were sprayed with derris and subsequently infested with a total of 304 aphid nymphs. Seven days later, after some reproduction had occurred, a total of 255 aphids were present on the plants, which is equivalent to 84 aphids for every 100 aphids of original infestation.

Four pots of peas sprayed with nicotine and subsequently infested with a total of 48 aphid nymphs contained, at the end of seven days, a total of 680 aphids, or 1417 aphids for every 100 aphids of original infestation.

Thirteen pots of peas, untreated and infested with a total of 181 aphid nymphs, contained at the end of seven days a total of 3138 aphids, which constitutes 1734 aphids for every 100 aphids of original infestation.

At the close of the experiment, then, the derris-treated plants had less aphids than were present in the original infestation. The nicotine-treated plants had 17 times as many aphids, and the untreated plants had 21 times as many aphids as were present on the derris-treated plants.

Daily observations revealed that the majority of the original aphids placed on the derris-treated plants died in 48 to 72 hours. A slight degree of reproduction occurred on some of the derris-treated plants, but the young nymphs did not develop normally and the majority eventually died.

It is apparent from these results that derris spray, containing either of the two spreaders and wetting agents used in these experiments, protects potted pea plants artificially infested with the pea aphid for a

period of seven days against any building up of the original infestation of the pea aphid.—9-9-36.

Literature Cited

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Scientific Notes

Cerambycids Captured in Codling Moth Bait Traps.—While making examinations of bait traps for codling moths in an orchard near Orleans, Ind., during the spring of 1934, the authors observed that the traps were capturing a considerable number of beetles of the

Cerambycids Captured in Codling Moth Bait Traps

Species*	No. Taken		Earliest Date	Latest Date
	1934	1935		
Chion cinctus (Drury)	2	2	5–13	7–27
Cyllene caryae Gahan		1	5–3	5–3
Cyrtophorus verrucosus (Oliv.)	2		5–15	5–15
Derobrachus brunneus (Forst.)	2	3	6–26	8–7
Eburia quadrigeminata (Say)	95	105	6–29	8–21
Elaphidion mucronatum (Say)	28	107	6–2	9–1
Euderces picipes (Fab.)		1	6–17	6–17
Hypermallus incertus (Newn.)	33	43	6–21	8–20
Hypermallus villosus (Fab.)	7	146	5–8	7–22
Leiopus alpha (Say)		1	6–3	6–3
Leiopus variegatus (Hald.)		1	6–3	6–3
Leptura emarginata L.	4	9	6–8	7–15
Lepturges symmetricus (Hald.)		1	7–25	7–25
Neoclytus mucronatus (Fab.)	10	37	6–23	9–1
Neoclytus scutellaris (Oliv.)	10	69	6–22	9–20
Ophistomis (*Strangalina*) *luteicornis* (Fab.)	1	1	6–12	7–6
Phymatodes aereus (Newn.)	1		7–23	7–23
Phymatodes amoenus (Say)		2	5–11	5–13
Phymatodes varius (Fab.)		2	5–11	6–15
Physocnemum brevilineum (Say)		1	6–6	6–6
Pseudibidion unicolor (Rand.)	10	1	6–12	7–19
Purpuricenus axillaris Hald.	1	1	6–6	7–20
Purpuricenus humeralis (Fab.)	5		6–6	7–9
Rhopalophora longipes (Say)		1	7–1	7–1
Romaleum atomarium (Drury)	5	16	6–29	9–18
Romaleum rufulum (Hald.)		2	7–15	7–25
Smodicum cucujiforme (Say)		1	7–20	7–20
Stenocorus cinnamopterus (Rand.)		1	5–10	5–10
Stenosphenus notatus (Oliv.)		6	5–10	5–13
Typocerus lugubris (Say)	1		6–24	6–24
Typocerus velutina (Oliv.)	7	8	6–20	6–24
Xylotrechus colonus (Fab.)		6	7–13	8–19

* The specimens captured in 1934 were determined by W. S. Fisher of the U. S. Bureau of Entomology and Plant Quarantine. Those captured in 1935 were determined by John M. Amos and the identifications verified by Mr. Fisher.

family Cerambycidae. Records were kept from this time on through the seasons of 1934 and 1935. Thirty-two species and 24 genera were represented, as will be seen from the accompanying table.

In 1934, the 31-acre bait area had 1000 traps in it. The type of trap used was the wide-mouthed fruit jar. The different baits, alternated by rows, throughout this area were:

(1) Ten per cent dark-brown sugar solution and oil of sassafras one-half cc. per quart.
(2) Ten per cent dark-brown sugar solution and citral one-half cc. per quart.
(3) Ten per cent blackstrap molasses solution and oil of sassafras one-half cc. per quart.

Bait solutions were renewed every 20 days. However, one-half of the traps were refilled at a time.

In 1935, the 24-acre bait area had 729 traps. The baits used, alternated by rows were:
(1) Ten per cent dark-brown sugar solution and oil of sassafras one-half cc. per quart.
(2) Ten per cent dark-brown sugar solution and bromstyrol one-half cc. per quart.

Baits were changed the same as in 1934.

Except for a few trees of hackberry and black walnut along the edges of the orchard and a few scattering trees in a pasture south of the orchard, there was no timber closer than 1½ miles.

Since the traps were not in place until May 14, and some of the men who examined the traps did not remove the cerambycids captured, the records for 1934 are incomplete. The records of the cerambycids captured, which include 32 species and 24 genera, are given in the accompanying table, which shows the number of each species captured each year and the earliest and latest dates of capture for each form.

This note should be of interest to any one collecting in this group as 14 of the 31 species were listed as scarce or rare by Blatchley in 1910 in his "Coleoptera or Beetles Known to Occur in Indiana." Two others were not recorded by him at that time as occurring in the state. *Eburia quadrigeminata*, *Elaphidion mucronatum* and *Neoclytus scutellaris* were among those reported by him as scarce. It will be seen from the table that they came fairly readily to the bait traps. Although the species was not necessarily scarce, specimens of *Leptura emarginata* were said to be difficult to secure.

S. A. Summerland and John M. Amos, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*—9-18-36

Bill-posters' Paste in Mite-control Sprays.—Parker (1913. U.S.D.A. Bur. Ent. Circ. **166**) found flour paste a good control of red spider. Glue is sometimes used for control of mites on evergreens. Both these materials have in repeated trials given satisfactory controls but are little used becouse the flour paste is hard to make, while glue foams and does not dissolve readily.

The above facts came to mind this past season when an infestation of *Tetranychus bimaculatus* Harvey developed in a Delicious apple planting which carried plenty of sulfur upon the leaves. Ordinary dry bill-posters' paste, 4 pounds in 100 gallons of water, gave complete control of the mites with one thorough application.

The advantages of using dry bill-posters' paste are apparently that it can be cut into the spray tank just like lead arsenate, it does not foam, it is economical, it is compatible with most insecticidal and fungicidal materials, and at the above strength does not discolor plants noticeably.

Following the success attained in spraying apples, bill-posters' paste was used against mites on raspberries, beans and dahlia with complete control. Bill-posters' paste, however, was of no value against leaf hoppers, flea beetles and tarnished plant bug nymphs and adults.

Ray Hutson, *Michigan State College, East Lansing.*—10-12-36

Control of Potato Flea Beetle, *Epitrix cucumeris* Harr.—On August 20, 1936, an informative test was conducted on a small area of tomato plants to determine the effect of *Cubor 75* dust (.75 per cent rotenone) and derris–gypsum dust (.4 per cent rotenone) on the control of potato flea beetles, which were present in exceptionally large numbers. The dusts were applied around 6 o'clock at night and within an hour the ground was thickly dotted with wriggling beetles. All these were dead the following morning.

On August 22 the patch was examined and no live flea beetles were found on the plants. Small areas 1 inch square were marked off on the ground below the plants and counts made of dead insects. None to 12 flea beetles were found per square inch, as well as an occasional aphis, potato beetle and lady beetle. The control of these insects appeared to be practically complete at the time of examination.

Ten days after this application the tomato plants were found to have occasional leaflets with three to five flea beetles present and feeding.

An adjacent unsprayed plot of potatoes was found to have none to 19 flea beetles per

leaflet actively feeding. These were given one application of 12:8:80 copper arsenate–lime dust on August 25 and a few days after treatment reexamined. The flea beetles were still present and feeding.

As the potato foliage was still healthy on the area undug on September 8, a further examination for flea beetles was made and none to 24 beetles per leaflet were found. The tomato vines on this date showed only the odd beetle, a remarkable illustration of the two methods of treatment.

The progress of the flea beetles through the potato plantings to the tomatoes was interesting. As the potatoes were dug, the infestation kept moving to the undisturbed plants in a uniform manner, and while there were beetles present throughout the whole area, severe infestation and definite foliage injury always occurred uniformly along the entire rows from the edge of the plantings inward, rather than in spasmodic patches.

Identification of the dead flea beetles showed the striped cabbage flea beetle, *Phyllotreta vittata*, Fabr., to be present in small numbers.

F. A. HERMAN, *Dominion Experimental Farms, Ottawa, Ont.*, and J. F. HOCKEY, *Dominion Laboratory of Plant Pathology, Kentville, N. S.*—10-13-36

Calcium Cyanide for Control of Squash Bug, *Anasa tristis* De G.—Pyrethrum activated "A" dust (a proprietary mixture), 4 per cent nicotine–line dust, and calcium cyanide ("A" dust) were tested for their effectiveness against the squash bugs of all stages during the summer of 1936. The efficiency of the nicotine and pyrethrum was negative or nearly so, while calcium cyanide was rather high.

Pack (1930. Utah Bul. 216: 21.) was apparently the first to recommend the use of calcium cyanide for combating this insect. Knowlton (1933. Utah Leaflet 2.) stated that a 20–40 per cent recovery occurs with calcium cyanide.

In tests conducted by the writer, the dust was applied with a bellows duster and counts were made 24 hours after treatment. Burning was noticeable on all the plants treated. The kill of the bugs was as follows:

	Replication	Alive	Dead
	1	16	240
	2	29	212
	3	24	481
	4	12	362
Total		81	1295

Efficiency 88 per cent

From observations of the insects' habits it was discovered that they congregate in groups on the ground each day beneath the plants about an hour before sunset. It occurred that a treatment made at this time might be more effective. Accordingly, in a second experiment the dust was directed on the ground beneath the plants, coating the bugs which had gathered there. The air conditions were optimum for applying the material. The kill of all hatched forms was essentially 100 per cent and no injury to the plants was observed. Apparently the bugs do not revive if they are hit directly with the dust.

JOSEPH B. MOORE, *New York Agricultural Experiment Station.*—10-9-36

Methyl Bromide Fumigation of Codling Moth Larvae.—In some walnut packing houses in California all empty sacks returned to the growers are vacuum fumigated to kill codling moth larvae. The sacks are tied into bundles of 50 and as many of these bundles are loaded into the fumatorium as possible, hydrocyanic acid gas and carbon disulfide being the fumigants used. With the short exposure (one or two hours) and the large amount of absorptive material in the fumatorium, it seemed rather doubtful as to whether the larvae were being killed. Ginsburg (1933) found codling moth larvae difficult to kill with both hydrocyanic acid gas and carbon disulfide. Using a very high dosage of 80 cc. per 100 cubic feet, Ginsburg obtained 100 per cent kill of the naked larvae, and with CS_2 he killed only 80 per cent of the naked codling moth larvae with 286 cc. per 100 cubic feet.

A series of experiments were conducted at the Citrus Experiment Station and one of the walnut packing houses in the fall of 1935 to determine if HCN gas or CS_2 gave complete control of the larvae within the burlap sacks. A dosage of 200 cc. of HCN per 100 cubic feet with a sustained vacuum of 26 inches and an exposure of one hour gave only 46 per cent

kill of naked codling moth larvae buried in the center of bundles of sacks. Using a dosage of 150 cc. of HCN per 100 cubic feet with a sustained vacuum of 26 inches and an exposure of four hours, 37 per cent of the larvae were killed. Only 15 per cent of the larvae were killed with a dosage of 3 pounds of CS_2 and a large amount of CO_2 per 100 cubic feet. These dosages were much higher than had been used in any of the packing houses.

Upon obtaining such poor results with hydrocyanic acid gas and carbon disulfide, other fumigants were tried and one in particular showed much promise. This was a commercial product which contained 3.4 per cent methyl bromide and 96.6 per cent carbon dioxide. In a series of tests this product used at the rate of 5 pounds to 100 cubic feet gave a complete kill of the codling moth larvae buried in sacks. Five pounds of this material contains approximately 2.8 ounces of methyl bromide. It appears as though methyl bromide is much more toxic to codling moth larvae than is HCN or CS_2.

D. L. LINDGREN, *University of California Citrus Experiment Station, Riverside.*—10-26-36

***Amelia (Tortrix) pallorana* Robinson Attacks *Pinus* sp.**—Late in May 1936, a small green tortricid larva was discovered attacking the new growth of *Pinus* spp.

Specimens were referred to Dr. August Busck of the U. S. National Museum, who determined them to be *Amelia pallorana* Robinson. At least two infestations occurred in the state, one at East Lansing, the other at Augusta, Mich. The most serious injury occurred at Augusta. This plantation covered some 200 acres in grass sod and consisted of a mixed stand of four to six-year-old white, red, Scotch and Jack pine. All pines were attacked but the larvae showed a decided preference for white pine. They confined their injury to the tender new growth, drawing the young shoots together and fastening them with loose webs. They did not restrict their feeding to the tender needles but also tunneled into or hollowed out the new growth. At least 95 per cent of the new growth of white pine was killed or deformed while other species of *Pinus* were injured to a lesser degree.

A second brood of larvae appeared in August but they did not attack pine. Apparently the new growth was by that time unsuitable for food.

While the infestation was not discovered until in the spring of 1936, it is evident that this insect or one of similar habits has attacked the new growth both in 1934 and 1935.

E. I. MCDANIEL, *Michigan State College, East Lansing.*—10-22-36

Method of Rearing Corn Earworm Larvae.—Owing to the cannibalistic habits of larvae of *Heliothis obsoleta* F. it has been necessary heretofore to isolate them in individual containers in order to rear them successfully. This has involved a great deal of labor in handling containers to keep fresh food before the larvae. A simpler method of rearing these larvae, for maintenance of a stock for study or for other purposes, has been greatly desired. During 1935 and 1936 such a method of rearing was developed in New Haven, Conn.

This rearing method is made possible by the following two facts: (1) Corn ears picked before the tenth day after silking remain fresh and suitable as larval food for a sufficient time to enable larvae to complete development when feeding in them. Although the husks of such ears, whether kept indoors or in shade or sun outdoors, wither and turn brown, the incipient cobs within are found to be fresh and moist after the lapse of from two to three weeks, the kernels apparently having undergone little change detrimental to the larvae during such a period. (2) Earworm larvae do not usually migrate from the ear on which they are hatched except in cases of overpopulation and resulting severe competition. Newly hatched larvae usually enter an ear when placed on its silk.

Because of these two facts the ears may be harvested, one or two newly hatched larvae may be placed on the silks of each, the ears may then be laid aside, and the full-grown larvae may be recovered as they leave these ears to seek pupal quarters two to three weeks later. It has been found most convenient to impale the cobs of the ears on nails driven through boards, thus facilitating handling them in quantity.

To maintain a stock of the insects the writer has adapted the features mentioned into what is, in effect a miniature cornfield. A bottomless cage 3 feet wide, 4 feet long and 2 feet high was constructed of 1 by 2-inch wood and copper screening. Boards 8 inches in width formed the lower portion of the cage, and a hinged door was placed above the board at one side. The cage was placed on a cement slab and 8 inches of soil was placed therein. Eight 1 by 2-inch boards, with nails driven through them $2\frac{1}{2}$ inches apart, were fashioned to fit into grooves placed along the front and the back of the cage an inch or more above the soil. A cover of roofing paper was placed on the cage to exclude rain. Ears as described were obtained, infested with two newly hatched larvae apiece, and impaled on the nails

provided in the cage. The nails were sufficiently far apart on the board strips and the latter were so spaced that the ears did not touch one another or the sides of the cage, thus minimizing the likelihood of migration of the larvae. In this cage the full-grown larvae could leave the ears and enter the soil to pupate naturally. The moths might be recovered as they emerged, or larvae or pupae might be taken if desired. If a few ears infested with newly hatched larvae were introduced daily over a period of two weeks, a continuous supply of moths might be had.

In one lot of 98 corn ears infested and placed, on August 5, in a cage as described, 122 larvae were recovered on August 25. On this date 88 of these larvae had become full grown and had left the ears to enter the soil, 18 were ready to leave the ears, 13 occurred as of the sixth or last instar, while three were recovered as fifth-instar individuals. In 67 ears one larva had matured, in 27 two had developed, while three larvae occurred in one ear. The 122 larvae recovered, developing in 95 of the 98 ears, were 62 per cent of the 196 placed on the ears. Two newly hatched larvae were used per ear because it has been found that infestation is more likely to occur when the ears are thus infested than when only a single larva is used per ear.

The larvae reared as described were normal in all respects, were as large as the larvae that usually occur on corn, and had matured in the usual period. The little labor required in rearing caterpillars by this method suggests that in larger cages, or in series of them, any required number of larvae might be obtained, depending only on availability of young corn ears and newly hatched larvae.

GEORGE W. BARBER, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*—10-19-36

Lesser Wax Moth Found in Oregon and California.—We now have definite data proving that the lesser wax moth, *Achroia grisella* Fabr., occurs in southern California and in Oregon. Numerous specimens were taken in Orange county, Calif., September 17, and a few specimens were also taken at Junction City, Ore., September 25, 1936.

The damage occasioned by this species appears to be very minor. Larvae were active inside the occupied hives, but the tunnels were hard to find; this being in sharp contrast to the condition observed where the greater wax moth, *Galleria mellonella*, is found.

The adult specimens collected were identified at the U. S. National Museum by Carl Heinrich.

GEO. H. VANSELL, *Pacific States Bee Culture Field Laboratory, Davis, Calif.*—10-19-36

***Leptocoris trivittatus* Say Killed by a Sulfonated Higher-alcohol Spray.**—A sulfonated higher alcohol used as a contact spray was found effective in controlling the box elder bug, both in the adult and immature stages. The grade used was one commonly sold across grocery counters as a cleaning compound.

Various strengths were used but it was found that 1 teaspoonful of the dry powder to 1 quart of water was sufficient.

Sulfonated higher alcohols also have an advantage in that they do not injure vegetation nor spot paint.

E. I. MCDANIEL, *Michigan State College, East Lansing.*—10-22-36

MASSACHUSETTS STATE COLLEGE CELEBRATES FERNALD SEMICENTENNIAL

The fiftieth anniversary of the beginning of the work of Dr. Charles Henry Fernald, one of the founders of economic entomology in this country and an authority in economic entomology, was celebrated at Massachusetts State College on October 16. Dr. Fernald founded the department of entomology at Massachusetts State College in 1886. He died at Amherst in 1921. Dr. W. E. Britton, state entomologist of Connecticut, presided at the formal exercises. The speakers were President Hugh P. Baker, of the Massachusetts State College; A. F. Burgess, of Greenfield, entomologist with the federal Moth Control Laboratory, who has carried on the work of gypsy moth control begun by Dr. Fernald in 1886, and Dr. E. Porter Felt, director of the Bartlett Tree Research Laboratory, Stamford, Conn.—*Science* **84** (2182):366. Oct. 23, 1936.

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PROGRESS IN COOPERATION

IN the conclusion of an address made by the writer fifteen years ago the following statements were made: "If economic entomology is to fulfill its destiny and keep abreast with the rapid growth of other biological sciences and the marvelous development of agriculture; if it is to continue to make notable contributions to the progress of the nation and the world; if it is to develop on that broad and constructive plane so necessary for the rendering of maximum service and usefulness; if it is to accomplish achievements of such importance as to be the subject of favorable comment and receive the commendation of the general public, there must be a closer cooperation and a more sympathetic and generous attitude; first, between state and federal entomologists; second, among state entomologists engaged in similar entomological problems; third, between entomologists and other biological scientists; fourth, between entomologists and medical men; fifth, between entomologists and industrial enterprises; sixth, between entomologists and sanitation engineers; and seventh, between all of these and the general public."

At the present time it is not only interesting but also gratifying to note some of the accomplishments of the last fifteen years. There has been the formation and establishment of the Cotton States Branch of Entomologists, the Eastern States Branch, the North Central States Entomologists, the Rocky Mountain Conferences of Entomologists, the four regional plant boards, the National Plant Board, the several state and regional entomological societies and many other entomological groups. Through the Crop Protection Institute the entomologists and plant pathologists have found a splendid organization to conduct cooperative work with industrial concerns, and with their cooperation and support many worth-while accomplishments have been had. Through the reorganization of the federal Bureau of Entomology and Plant Quarantine and a change in location of several of the research laboratories, there exist a closer cooperation and a more sympathetic and generous attitude between the federal and state workers which have brought about a stimulation and unity of interest, and efficiency of entomological efforts. Federal cooperation and financial aid in conducting insect surveys and control measures for many major pests, such as the gypsy and browntail moths, Japanese beetle, cotton boll worm, pink boll worm, Mediterranean fruit fly, European corn borer, chinch bug, grasshoppers, alfalfa weevil, mosquitoes, screw worm fly, Dutch elm disease, phony peach disease and peach mosaic, have been of inestimable

value to the general public. The timely information, the news letters, the entomological technic circulars, the extension service, the motion picture service, and the entomological conferences have been valuable and helpful.

With the fine spirit of cooperation and generous attitude which is so general among entomologists, plant pathologists, plant geneticists, bacteriologists, agronomists, horticulturists, chemists, physicists, agricultural engineers and the general public, and with well-trained research men with inspiration, interest and zeal, entomology is certain to continue to make not only notable contributions to the progress of the nation and the world, but also to develop on a broad, constructive plane for the rendering of maximum service and usefulness.

GEO. A. DEAN.—10-31-36

Obituary

Justus Watson Folsom 1871–1936

Justus Watson Folsom, teacher and investigator, died at Vicksburg, Mississippi, September 24, 1936, at the age of 65, after an illness of several weeks following heart attacks.

Dr. Folsom was born in Cambridge, Mass., September 2, 1871. From Harvard University he received the degree of Bachelor of Science in 1895 and Doctor of Science in 1899. His studies in the graduate school of Harvard University resulted in his first scientific masterpiece on the segmentation of the insect head. For one year (1899–1900) he was professor of natural science at Antioch College, Yellow Springs, Ohio. In 1900 he went to the University of Illinois as instructor in entomology. From the beginning he was a popular and enthusiastic teacher. One of his early students, who is now a county agricultural agent in Indiana, recently wrote me as follows: "I was a student under Dr. Folsom at the University of Illinois and enjoyed every moment in his classes. He seemed to possess a rather rare ability to make students want to learn–something all instructors do not have. He was exacting, yet congenial and a good fellow always." He will be remembered by his many students for his quiet and unassuming ways and his constant interest in their welfare. He was thoughtful of others and ever ready to postpone his own work to aid those who needed encouragement and help, but always fostering student initiative.

JUSTUS WATSON FOLSOM

It was in his early years at Illinois that he conceived and completed his justly famous textbook "Entomology With Special Reference to its Biological and Economic Aspects." At present, 30 years after the publication of the first edition, this book is still a standard, and in the field of insect morphology, physiology and bionomics, remains the standard text in those fields as does Comstock's "Introduction to Entomology" in the field of taxonomy. Perhaps no technical treatise has ever been written which is as understandable and readable.

Dr. Folsom remained at Illinois for 23 years, during which time he was assistant professor (1906–1908) and associate professor (1908–1923).

In 1925 he received the appointment of associate entomologist in the U. S. Bureau of Entomology, giving his entire service to the time of his death to a study of cotton insects, with headquarters at Tallulah, La.

Dr. Folsom held a wide interest in many phases of entomology, including anatomy, physiology, embryology, taxonomy and economics. His taxonomic studies dealt with the orders Collembola and Thysanura, in which field he was a world authority. His early economic studies dealt chiefly with clover and alfalfa insects, later conducting research on cotton insects. It is noteworthy that in every field of endeavor, Folsom produced outstanding results.

Dr. Folsom was prominent in scientific organizations. In 1900 he served as president of the Cambridge Entomological Club. He was a fellow in the American Association for the Advancement of Science and in the Entomological Society of America, serving as president of the latter association during 1931. He was a member of the American Association of Economic Entomologists, serving as chairman of the Cotton States Branch and vice-president during 1932. He was also a member of the Ecological Society of America.

A beloved and inspiring teacher, a taxonomist of great ability and superior interpreter of the entomological sciences has been lost to entomology. His published studies will stand as everlasting memorials of his services to entomology.

J. J. DAVIS.—10-23-36

Reviews

Pyrethrum Flowers, by C. A. Gnadinger. 1936. Cloth, xvi+380 pp., 53 figures. McLaughlin Gormley King Co., Minneapolis, Minn. $5.

This is a much enlarged and improved second edition of the original which appeared in 1933. It deals with the subject of pyrethrum in an all-inclusive manner from the early history of the use of the crude product through the successive stages of the development of the present standardized form and finally discusses the possible sources of pyrethrum flowers in the United States.

An author reference of 991 citations in alphabetical arrangements is a fine contribution to the world literature on insecticides. These references are used freely in the support of statements made in the text.

It is refreshing and encouraging to observe a commercial concern willing to expand both talent and funds in an effort which has yielded results, at least some of which a few years ago would have been retained for its individual use.

The book is a valuable addition to the library of any institution or individual concerned with insecticide research as well as to insecticide manufacturers and dealers and to producers of pyrethrum.

J. S. HOUSER —10-5-36

Insect Pests of Glasshouse Crops, by Herbert W. and Mary Miles. 1935. Cloth, x+174 pp., frontis. +86 figs. (21 pls., 15 text), index. The London Caledonian Press Ltd., 74 Swinton St., Gray's Inn Road., London. 8s. 6d. net (by post 9s.).

In this book Herbert W. and Mary Miles have given "an account of pests that occur in glasshouses, and of control measures that are suitable for dealing with such pests under the special conditions of glasshouse horticulture."

The work is composed of nine chapters. The first chapter treats of the relation of glasshouse conditions to occurrence and control of pests. One chapter is devoted to general soil pests with a separate chapter on eelworms. There are five chapters devoted to a discussion of glasshouse pests feeding on the aerial parts of plants. Under the heading of each individual pest is given a brief account of the losses occasioned by the pest, its distribution, a popular description of its appearance and characteristics together with notes on its life history and habits. At the end of the discussion for each pest control measures are given. In addition an entire chapter is devoted to insecticides and appliances used for pest control in glasshouses.

The book contains two appendices and an index. The first appendix gives an alphabetical list of chief glasshouse crops with associated pests and their characteristic injury, the second gives a selected bibliography.

The book is well illustrated, well printed and apparently free from typographical errors.

It is written in a style suitable for the layman, although some of the terms are not clear to the American reader. Conditions existing in European glasshouses are so different from ours that recommendations which are entirely practical in England are unsuited for use in America. The rather free use of naphthalene fumigation in England without plant injury is in contrast to the results obtained under practical conditions in this country

A number of pests are covered which do not occur or are of negligible importance in America. On the other hand, a number of important pests of this country are not included.

C. C. COMPTON.—10-1-36

Horticultural Inspection Notes

ACCORDING TO R. P. Colmer, chief inspector of the State Plant Board of Mississippi, a recent order has been issued by that board prohibiting cabbage plants from being transported into or within Mississippi without a certificate of inspection and certification. This order became effective on October 6, 1936.

THE FEDERAL Bureau of Entomology and Plant Quarantine announces quarantine modifications covering the release of Florida from the areas designated as infested with the pink bollworm of cotton, the release of areas in Pinal county, Ariz., from the areas designated as infested with the Thurberia weevil, and the revision of regulations governing sanitary export certification, taking cognizance of the extension of the authority to inspect products not heretofore certified for export.

STATE PLANT QUARANTINE OFFICERS MEET NOV. 5–7

A conference of state plant quarantine officers was called by the National Plant Board at Chicago, Ill., November 5 to 7. The meeting was held at the Congress Hotel, there being more than 60 in attendance, representing 30 states. The program was as follows:

Thursday Afternoon, November 5, 1:30 p. m.

Meeting called to order
Report of Secretary
Appointment of Resolution Committee
Uniform Plant Certification and Standards of Inspection, *B. M. Gaddis.*
Uniform Requirements for Interstate Movement of Nursery Stock: Report of Standing Committee by Central Plant Board, *J. Carl Dawson.*
General Discussion of Report
Status of Post Office Terminal Inspection and Standardization of State Quarantines, *A. C. Fleury.*

Friday Morning, November 6, 9:30 a. m.

National Quarantine Problems, *L. A. Strong.*
Status of Dutch Elm Disease Eradication, *L. H. Worthley.*
Gypsy Moth and Brown-tail Moth-control Operations for the Calendar Year 1936, *A. F. Burgess.*
Transit Inspection, *B. M. Gaddis.*
Some Phases of Enforcement of Foreign Plant Quarantines, *E. R. Sasscer.*
Report on the Control of Black Stem Rust and White Pine Blister Rust, *S. B. Fracker.*

Friday Afternoon, November 6

Discussion of Reports
Report of Resolution Committee

Saturday Morning, November 7, 9:30 a.m.*

Report on Present Status of Japanese Beetle Quarantine, *L. H. Worthley.*
Discussion of Report

* Subject conference may be advanced to Friday afternoon if time permits for attendance only of state quarantine officials.

THE MISSISSIPPI STATE PLANT BOARD amended their Rule 64A relating to the phoney peach disease on October 6, 1936, regulating the shipment of peach, nectarine trees and their roots or any tree or shrub grafted on these roots into and within that state, requiring in addition to the regular nursery inspection certification a special peach certificate. This certificate must show that the stock was produced either in a county free from the disease or in a nursery and an environs of 1 mile free from the disease or that each plant has been hand-inspected after digging and found free of infestation by the peach-tree borer.

THE ALFALFA WEEVIL quarantines of Kansas and Wisconsin were re-issued October 15, adding to the area designated as infested Eagle county, Colo., Box Butte and Dawes counties, Neb., Harney county, Ore., and Falls River county, S. D. The Oregon and Colorado quarantines relating to the weevil were also emended, the former lifting certification requirements relating to potatoes, and the latter providing that certified native hay may be shipped to Colorado in winter, from Carbon county, Wyo., the third Wyoming county for which such provision has been made.

ALL REFERENCE to potatoes and alfalfa seed were eliminated in the new California quarantine relating to the alfalfa weevil which became effective August 5. "Elimination of the potato screening and certification requirement is occasioned by the fact that the present method of handling potatoes in the intermountain area involves no association with alfalfa hay and precludes the possibility of their transporting alfalfa weevil," according to the announcement accompanying the notice. The quarantined areas were extended in the revised quarantine, adding Montezuma and San Juan counties, Colo., and Clark county, Nev.

TWENTY-FIRST ANNUAL MEETING OF THE PACIFIC SLOPE BRANCH OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Held in Seattle, Wash., June 18 and 19, 1936

The meetings of the Pacific Slope Branch were held at the University of Washington, Seattle, on June 18 and 19, under the chairmanship of Dr. H. A. Scullen, Corvallis. Between 50 and 60 members and persons interested in entomology attended the various sessions. A total of 35 papers were listed on the program and the invitation address was presented by Professor R. W. Doane of Stanford University, who gave a most interesting talk on "Forty-Five Years of Entomology."

Some most interesting papers were presented, four of which were devoted to the codling moth. On the evening of the eighteenth the banquet was held, at which about 40 were present. It was a most interesting occasion and short addresses were made by a number of those present.

In addition to members resident on the Pacific coast, there were in attendance a number of entomologists from much farther afield, including Dr. Chapman from Hawaii, Dr. Roark from Washington, D. C., Drs. Crosby and McLeod from Cornell, Mr. Fenton from Texas, and Mr. L. S. McLaine from Ottawa, Can.

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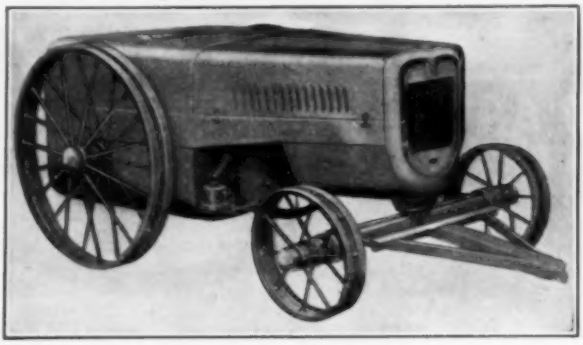

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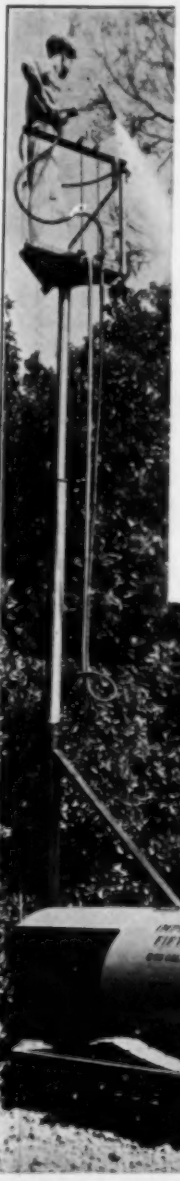

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